23,103/B/~~III~~ 1

A/o

Bound down with Care, with sorry spent
Poor dear Miss Peile to Barmouth went
But what of that; why should not she
As well as others have a spree

* * *

And of this fact there is no doubt
That she deserved a pleasant out.
She discharged her duties well
Stop p'rap twould make her blush to tell

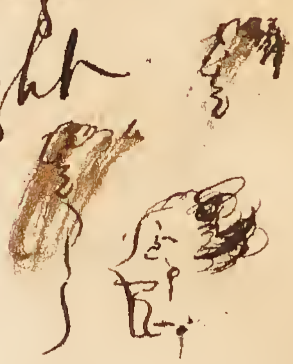
The sun indeed quite glorious beamed
And set ~~ff~~ fair the weather seemed
Nature put on its brightest face
As in the train she took her place

Away she went ~~on th~~
on pleasure bent But how the fun
The engine shrieked the train moved on
but scarcely a dozen ~~sixty~~ miles had gone

When ah alas the wind veered round
And whistled with a doleful sound

— " —

The gathering clouds obscured the sun
And ~~fast and still~~ sadder still the rain began
It seemed at first a summer shower
But still it never ~~seemed~~ ceased to pour
But heaven still . fill-
With right good will .
In old torrents it came down
~~[illegible]~~ th ~~high [illegible]~~ blew
Became a [illegible] storm.
~~The Elemental war still raged~~
The Storm still raged without compunction
All though she changed at mote lane Junction
Barmouth she reached ~~but what a sight~~ at length all right
The landscape seemed a dreary sight
She met her friend
And they did went
their way soon home to tea .
And hoped the morning sun would find
the weather changed to beau .



Fatigued she ~~[illegible]~~ retired to bed
And tried to rest her weary head
But all in vain the surging deep
Made too much noise to let her sleep

The wind was strong
And all night long ~~[illegible]~~ [illegible]
Blew off upon
~~The~~ angry sea with sullen roar
waves came boom [illegible]
rebellowed on the rocky shore
roar for roar

~~[illegible]~~
sea
The sullen roar —
~~[illegible]~~
[illegible]
Rebellowed on the shore

[illegible]

A
GENERAL SYSTEM
OF
CHEMICAL KNOWLEDGE,

&c. &c.

The Young

The Young [illegible]

The Young [illegible] [illegible]

[illegible]

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A GENERAL SYSTEM OF CHEMICAL KNOWLEDGE;

AND ITS APPLICATION TO THE PHENOMENA OF NATURE AND ART.

BY A. F. FOURCROY,

Of the National Institute of France, Counsellor of State, Professor
of Chemistry at various Public Establishments, Member
of many Academies, &c.

IN ELEVEN VOLUMES.

TOGETHER WITH A SET OF SYNOPTIC TABLES, IN LARGE FOLIO.

TRANSLATED FROM THE ORIGINAL FRENCH,

BY WILLIAM NICHOLSON.

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A
SYSTEM
OF
CHEMICAL KNOWLEDGE.

SECTION SIXTH.

Concerning the Metals.

Article I.

Of the General and Comparative Properties of the Metals, and their Claſſification.

Section I.

Their Importance and Hiſtory.

1. IN the ſecond ſection of this work we conſidered the metals only as appertaining to the claſs of combuſtible bodies; and the general properties which I have deſcribed, were relative merely to their compariſon with the ſmall number of ſubſtances I had before treated. In the preſent ſection my object will be of much greater extent; namely, to deſcribe at length theſe brilliant bodies ſo uſeful in ſociety; which ſo

highly influence public and individual proſperity, not only by their real properties, but by the ideal value attached to them by men; which have on the one hand rendered ſuch eminent ſervices to humanity, and on the other produced ſo many evils; which at the ſame time mark the induſtry of nations, and add to the improvement of human reaſon, while they ſo often become the inſtruments, and almoſt the cauſe, of the depravation, the miſery, and all the evils which afflict mankind. There are no productions of nature which excite a higher degree of intereſt in their ſtudy, or which have given riſe to ſo many diſcoveries: there are not, conſequently, any ſubſtances which deſerve to be treated more at length, or with greater care.

2. The multiplied uſes to which the metals are applicable, do not conſtitute the only reaſon why theſe bodies ſhould be deſcribed with much accuracy, and ſtudied with the greateſt preciſion. The vaſt influence which they have had on the progreſs of chemiſtry, the diſcoveries which relate to them, particularly in modern times, and the perfection which they have added to human reaſon, render them of the moſt impreſſive conſequence to thoſe who cultivate natural philoſophy. On the properties of theſe bodies depend the mariners' compaſs, the arts of printing, of navigation and aſtronomy, and every other ſcience which are moſt truly honourable to the genius of man. There is, in truth, no

art which can be carried on without the metals. They are the firſt movers and primary inſtruments of almoſt every workſhop. There is ſcarcely a ſingle circumſtance of life in which we do not derive continual ſervices, or in which we are not ſubjected to dangers from their energy. The metals are friends which ſerve us, and which it is deſirable we ſhould always have near us; or they are enemies preſſed into our employ, which it is conſequently of importance that we ſhould know how to ſubdue, and ſometimes to coerce. The ſcience of medicine, which in all the regions of nature has ſought for defence againſt the evils which afflict humanity, and from which it would be perhaps dangerous to obliterate the illuſions of hope with which it ſurrounds the bed of ſickneſs, even when to cure is beyond its power; this ſcience has diſcovered in metallic ſubſtances a number of remedies which can never be conſidered with indifference, and of which the moſt ſublime chemiſtry is often called upon, either to determine the nature, to direct the activity, or to regulate the power according to the wiſh of the enlightened phyſician.

3. Though the accidental effect of certain natural events, or ſpontaneous fires, may have at firſt exhibited the metals to the obſervation of man, it is eaſy to conceive that rapid progreſs muſt have been made in the treatment of theſe ſubſtances. In the early infancy of chemiſtry, almoſt contemporary in this point of view

with the firſt ages of civilization; when we direct our attention to the heroic, fabulous, and moſt early ages; in theſe times we find that ſmiths and founders were actively employed. The plough-ſhare dates as early in point of time as the coarſe caſts of the gods in metal. But notwithſtanding this high antiquity of the metallic arts, in which the hiſtorians of chemical ſcience have been deſirous of fixing its origin, the ancients were in truth poſſeſſed of but a ſmall portion of real knowledge reſpecting the properties of metals.

Iron, copper, gold, and ſilver, have manifeſtly been the firſt known and employed. Tin and lead muſt have followed ſpeedily afterwards, if they were not diſcovered, even at the ſame time or before. The art of ſmelting, of caſting, of forging, and even of alloying them, muſt ſoon have ſucceeded; but the true chemical properties were long concealed in the boſom of nature, and diſcoveries of this kind were undoubtedly made with extreme ſlowneſs. The Greeks and the Romans were acquainted with only ſeven metals. It appears that ſome of thoſe which were ſince called ſemimetals were known to them only under peculiar names, and with notions foreign to that of their proper metallic nature. This is ſo much the more natural, as the property of ductility, which is the moſt uſeful to men, and of which they avail themſelves the moſt early, muſt always have connected itſelf with them as part of the notion of a metal. Even at preſent, notwithſtanding the vaſt maſs of information diſcovered reſpecting ſuch metallic bodies as are not ductile, and the numerous uſes to which moſt of them are appropriated, the greateſt part of men do not even now conſider any ſubſtances as metals but thoſe which are capable of being forged, flattened, drawn out, &c.

4. The follies and imaginary hopes of the alchemiſts and adepts, a diſeaſe of the human mind which it is ſo difficult to extirpate in the ſocial ſtate, and of which ſome veſtiges ſtill remain, though happily ſcattered, and little likely to propagate themſelves, have nevertheleſs proved the ſource from which all our chemical knowledge of the metals originated. The indefatigable patience of theſe men; the numberleſs experiments they made; the admirable law which they impoſed on themſelves to deſcribe with the greateſt care theſe experiments which did not afford their chemical reſult, at the ſame time that they carefully concealed thoſe which they affirmed to have ſucceeded, have gradually raiſed that edifice which Science began to poſſeſs from the middle of the ſeventeenth century, and which has ſpeedily been enlarged by the labours of the chemiſts, whoſe method, intelligence, and reaſon, have enabled them to diſpoſe with art all the ſhapeleſs materials, amaſſed with ſo much labour by the induſtrious ſearchers after the philoſopher's ſtone, and the univerſal medicine.

5. After the abſurd reſearches, though abounding with ſingular facts of Geber, Morien, Arnaud de Villeneuve, Raymond Lullius, Bernard Treviſan, Agrippa, Iſaacus Hollandus, Bazil Valentine, Philalethes, Morhof, Sendigove, D'Eſpagnet, and ſo many other celebratated enthuſiaſts, we behold, on the other hand, Libavius, Dorneus, Hahnemam, Gerhard, Caſſius, Wedel, Orſchall, and many other men of this order, buſy themſelves in extracting the pearls from this dunghill, ſeparating the uſeful facts from the ridiculous aſſertions, the valuable experiments from the myſtical operations, and by theſe means making an advantageous ſelection of the art; and though they were not intirely without credulity, as to the great work and the panacea, yet they reduced to order, and with a certain degree of ſkill, arranged the reſults of the obſervations of the alchemiſts, ſo far as to form the commencement of a theory reſpecting the properties of metallic ſubſtances.

6. Chemical metallurgy has been more particularly benefited by the works of docimacy and metallurgy, treated either as arts or as a ſcience, which have been publiſhed ſince the middle of the ſixteenth century to the end of the eighteenth, and particularly by thoſe which have been ſucceſſively printed by J. Q. Agricola, in 1546, Lazarus Ercker, 1574, Modeſtus Fachſius, 1622, Alonzo Barba, 1640, Aldrovandus, 1648, Borrichius, 1674, Fr. Henckel, 1725, Swedenborg, 1734, Schulutter, 1738, Cramer 1739,

Gellert, 1765, Lehman, 1761, Wallerius, 1770, Dellius, Gobet, Jars, Bergmann, Dietrich, Born, Ferber, and Pfingſten, in modern times. In all theſe works the treatment of ores and metals in the large or ſmall way, in the metallurgic, or docimaſtic methods, has been enlightened by the moſt perſpicuous theory, and deſcribed as a ſeries of chemical experiments, and conſequently connected with the general progreſs of the ſcience.

7. During the uninterrupted advance of the metallic arts for near two hundred years, towards a ſcientific doctrine, upon the progreſs and advancement of which they have had great influence, another ſtep of equal utility was made in the preparation, the nature, and the adminiſtration of medicines compoſed of the metals, and the art of making chemical experiments, the method of comparing them, and the drawing general inductions, or theoretic reſults. While we contemplate the abſurd and vain pretenſions of Paracelſus, Digby, and others, we muſt not overlook the uſeful labours of J. Silvius, Leo, Fachſius, Val Cordus, Quercetan, Mynſicht, Crollius, Zwelfer, Schroder, Fred. and Gaſp. Hoffman, Angelus Sala, Glauber, Charas, Nicholas Lemery, Barchuſen, Juncken, Pelletier, Shaw, Hermann, Wallerius, Perner, Poulletier de la Salle, Lewis, and Spielman. In the numerous writings of theſe pharmacological chemiſts, publiſhed between the years 1755 and 1775, we find a methodical diſpoſition,

tion, learned diſcuſſion, and neat deſcription of the chemical alterations which the metals are capable of undergoing by all the agents to which they are ſubjected, and thus modified, in their properties and nature.

8. It is in theſe valuable collections of facts, of experiments and of well-deſcribed phenomena, that the ſyſtematical chemical writers who are obliged to embrace the whole of the mutual re-actions of all the bodies in nature, upon each other, have found the elements of accurate knowledge, with which they have afterwards enriched their works. Without the laborious efforts of their predeceſſors; their treatiſes, far from being ſo complete as they were capable of making them, would, in all their ſections, have preſented immenſe vacancies in the exhibition of metallic matters, of which the properties conſtantly form the greateſt, and at the ſame time, the moſt important part of their works.

9. To theſe multiplied regiſters of experiment and reſearch concerning metallic ſubſtances, we muſt alſo join, in order to obtain a ſufficient knowledge of the hiſtory of that part of chemiſtry which concerns them, a knowledge of the numerous diſcoveries of new metals made, particularly ſince the commencement of the 18th century. During this period, diſcovery was made of arſenic, cobalt, nickel, and platina itſelf, before ſcarcely known. During the laſt twenty years, manganeſe, molybdena, tungſten, and recently uranium, titanium, and chrome,

have been added. All theſe metals which are very brittle, and more or leſs difficult to fuſe, remained long concealed and unknown to man, becauſe ductility had been conſidered as the inſeparable character of metallic ſubſtances. Since the ſeries of theſe ſubſtances has been diſcovered, which do not poſſeſs ductility, every fact ſeems to announce, that their number may hereafter be carried far beyond the preſent extent of our knowledge.

10. The courſe of ſucceſſive diſcovery and information thus gradually acquired, and which, I have here traced out, did not yet preſent any certainty of doctrine in the midſt of numerous facts which compoſed its totality. We may even add, that a great number of doctrines preſented errors of no ſmall magnitude, and that moſt of theſe facts were inaccurate ſketches before Lavoiſier publiſhed his happy diſcoveries reſpecting the calcination of metals, their ſolution in the acids, the decompoſition of acids, and particularly that of water, which many of theſe bodies effect. All the efforts of Bergmann to determine the proportion of an imaginary principle admitted ſince the commencement of the century, in metals, were little more than a confirmation of an ancient error; lending to that error, a factitious ſupport, until Lavoiſier, overthrowing by his ingenious experiments this falſe hypotheſis, created and cauſed to ariſe out of his new reſults reſpecting the nature of air, water, and the acids, a doctrine, which diſ-

pelled all the difficulties ſo abundant in the hiſtory of the metals, ſhowed the cauſe of their ſo frequent augmentation of weight, their reduction, their ſolution, and at length preſented them to chemiſts as indecompoſable paſſive inſtruments, indeſtructible with regard to their intimate compoſition, ſimply changing their form in all the alterations to which they are ſubjected; and acting, as the means of decompoſition on a number of compound bodies, the nature of which they are adapted to ſhow. Since this remarkable epocha, which muſt be conſidered as of importance to the progreſs of the human mind, the ſcience has advanced with a rapid courſe in the knowledge of the metals, and the determination of the phenomena they produce; diſcoveries have ſuddenly followed; every thing which was obſcure, has become enlightened; and this admirable department of chemiſtry, enriched with a number of new facts, has, at the ſame time, enlightened the workſhops of aſſays and metallurgy, together with mineralogy, and all the arts which employ the metals.

SECTION II.

On the Number and Claſſification of the Metals.

11. WHEN no other bodies were conſidered as metals but thoſe which poſſeſs ductility, and

when their number was confined to ſix or ſeven, it was not neceſſary to ſeek after many properties, nor to eſtabliſh any method for diſtinguiſhing and aſcertaining each of theſe bodies. The notion of forming a claſſification, muſt have ſcarcely occupied the attention of chemiſts.

12. At the period when the exiſtence of a number of brittle metallic matters was aſcertained, and it was admitted, that all their properties approach thoſe of the ductile metals, theſe began to be diſtinguiſhed by the terms, ſemi-metals, as if ductility were the moſt eſſential character of theſe bodies in nature, as it is in the uſes of art. Man, therefore, referring every thing to himſelf, and his events, gave to theſe beings a determinate rank and place from their utility to himſelf. Another idea, leſs reaſonable, no doubt, tended to confirm this expreſſion of the ſemi-metals. The alchemiſts imagined that all the metals were only efforts of nature towards the production of gold, conſidered as the moſt perfect of metals, and that, by a ſubterraneous operation of nature, inimitable by art, they were capable of arriving at a ſtate of maturity and perfection ſo as to become gold; and that all the metals were only ſucceſſive ſtates from a leſs to a greater degree of perfection, unto the laſt ſtate, namely, aurification. Now, as ductility is one of the moſt prominent characters of gold, and the metals properly ſo called, approach more or leſs to it by this character; thoſe metals which did not

poſſeſs it, appeared to them to be the firſt eſſays of nature, the embryos or metallic germs not yet developed. Hence, the expreſſion of ſemi-metals to deſignate ſuch bodies as had not undergone more than a ſemi-metallization.

13. But the moſt ſimple reflection is ſufficient to ſhow, that the application of the ſame idea muſt have led to the diſtinction of third parts of metals, and metallic fractions which might expreſs the ratio or proportion of metallic properties which each of theſe bodies appeared comparatively to poſſeſs. This ſuppoſition ſhows the falſity of the expreſſion of ſemi-metals, for it ſhows, that while it is defective as a true term of compariſon to expreſs the proportion of the metallic properties, chemiſtry would admit an erroneous and ridiculous language, by ſuppoſing, that the metals might in that manner paſs from one to the other converſion; a converſion, which art has never been able to effect, nor can it be ſhown by any obſervation, to have been effected in the proceſſes of nature.

14. It is no leſs evident, that we may apply the ſame remarks to the words *imperfect metals*, which was adopted to denote ſuch metals as burn, and eaſily loſe their metallic properties, and the name of *perfect metals*, which was given to thoſe which are very difficultly combuſtible or alterable in compariſon to the former. For this expreſſion, depends ſtill more on the imaginary tranſmutation, than the former term of ſemi-metals; ſince they affirm a pretended per-

fection in the one, and an imperfection in the other, which ſuppoſes a power of coming to perfection, and arriving at the ſtate of the former.

15. Rejecting, therefore, theſe hypothetical terms infected with the opinions of the alchemiſts, and aware of the neceſſity of arranging the metals methodically, it became requiſite, that diſtinctions ſhould be admitted among them, derived from properties eaſily appreciated and comparable with each other. Three properties, compared together, will ſerve to eſtabliſh the claſſifications of the twenty known metallic ſubſtances, namely, acidification, oxidation, and ductility; I divide the metals into five claſſes, in the following manner:

16. In the firſt claſs, are comprehended, the brittle and acidifiable metals; which are ſuceptible of aſſuming the characters of acids, by the combination of a greater or leſs proportion of oxigen. In this claſs, are four ſpecies, namely,

Arſenic,
Tungſten,
Molybdena,
Chrome.

There is no doubt, but that a greater number will hereafter be diſcovered.

17. The ſecond claſs includes metals brittle like the former, but not like them acidifiable. Theſe cannot be carried beyond the ſtate of oxidation, whatever may be the quantity of oxigen

applied to them. This claſs contains eight ſpecies, namely,

Titanium,
Uranium,
Cobalt,
Nickel,
Manganeſe,
Biſmuth,
Antimony.
Tellurium,

It may be remarked, that of all the five claſſes this is the moſt numerous.

18. To the third claſs appertains metals ſimply oxidable like thoſe of the ſecond claſs, but which differ from it by a commencement of ductility. Two metals only compoſe this third diviſion, mercury and zinc. The firſt congealed at a temperature of 32 degrees below 0, of the thermometer of Reaumur, may be flattened by percuſſion. It is the leaſt numerous in ſpecies of the five claſſes. The metals of theſe three firſt claſſes were formerly called ſemi-metals.

19. In the fourth claſs, I place the very ductile metals differing in this reſpect from thoſe of the preceding claſſes, which were only ſlightly, but eaſily oxidable, and diſtinguiſhed by that character from the following claſs. In this claſs are four metallic ſubſtances,

Tin,
Lead,
Iron,
Copper,

Theſe four metals formerly compoſed the ſeries of imperfect metals.

20. Laſtly, the fifth claſs comprehends the very ductile metals ſo difficulty oxidable or alterable, that a few years ago, they were deſignated by the expreſſion of perfect metals, as admitting the moſt perfect aſſemblage of all the metallic properties. The three ſpecies which formed this claſs are,

Silver,
Gold,
Platina.

21. From this diviſion and arrangement of the twenty-one known metals, there already reſults a notion of conſiderable accuracy reſpecting certain properties, and particularly thoſe by which theſe bodies are rendered moſt uſeful to ſociety. According to this method we might purſue the various compariſons to be pointed out in the following paragraphs relative to the generic properties of metals, before we paſs to the individual hiſtory of each.

SECTION III.

On the Phyſical properties of the Metals.

22. IN order to underſtand the characters and phenomena preſented by the metals, it is neceſſary in the firſt place to form a proper notion of their phyſical properties, without, however,

ever, entering into an extenſive detail which belongs to other branches of human knowledge. Among a number of properties perceptible to our ſenſes which may be meaſured and eſtimated, and do not change the nature of the metals, I reckon, 1. Their brilliancy, 2. Colour, 3. Denſity or weight, 4. Hardneſs, 5. Elaſticity, 6. Ductility, 7. Tenacity, 8. Conductibility of caloric, 9. Dilatability, 10. Fuſibility, 11. Volatility, 12. Cryſtallizability, 13. Electricity, 14. Odour. We muſt reſume each of theſe properties with ſome developements.

23. Brilliancy, is a character ſo evident in metals, that it has been denominated the metallic brilliancy. It ariſes from a complete reflexion of the luminous rays by metallic ſurfaces. They form mirrors which reflect the perfect images of objects. If any other minerals or foſſil ſubſtance ſometimes preſent an appearance of brilliancy, as we ſee in mica, of which the firſt avaricious conqueror of Peru was the dupe, when he took them for ſilver and gold, this illuſion is deſtroyed, when the falſe brilliant is ſcratched with a point, whereas the metal by the ſame treatment is no leſs brilliant in the excavated line, than on the ſurface. With regard to the gradation of this property, the metals may be placed in the following order,

Platina,
Iron and ſteel,
Silver,

Mercury,
Gold,
Copper,
Tin,
Zinc,
Antimony,
Biſmuth,
Lead,
Arſenic,
Cobalt, and the other brittle metals.

24. Colour, is a conſtant property inherent to the intimate nature of metals, whereas it is accidental, and not ever ſpecific in other foſſils, and as the metals are the moſt opaque, and the moſt denſe bodies in nature, their colour is very intenſe, or rather confounded with the brilliancy which depicts it ſtrongly in our eyes; it may therefore be conſidered as a ſpecific character. White is the moſt common colour of the metals, but there are alſo yellow and red. The former were diſtinguiſhed by the name of the lunar metals, becauſe ſilver, or luna, which was placed at the head of theſe metals is a white colour; and the ſecond were denominated ſolar metals, becauſe of the yellow colour of gold, which bore the ſignature of the ſun. By a more accurate examination of the metals as to their colour, we find them grey, as in iron, molybdena, tungſten, uranium, manganeſe; blueiſh as lead and zinc; yellowiſh as biſmuth; reddiſh-grey, cobalt; reddiſh-white, nickel. Though the colour be

permanent in the metals, while they themſelves are ſuppoſed to be in a permanent ſtate, it nevertheleſs is very eaſily changed in thoſe bodies by the ſlighteſt combination.

25. Denſity of maſs, or quantity of matter contained under a given volume; whence the ſpecific gravity that reſults is greater in the metals, than in any other natural bodies. It is concluded, that their particles are nearer to each other, and that their pores are ſmaller than can be imagined in any other bodies. This denſity is the cauſe of their brilliancy.

The metals when compared by this property, ſtand with regard to each other in the following order, ſuppoſing pure water, to which they are all compared to have the

Specific gravity,	1,00
Platina	20,85
Gold	19,258
Tungſten,	17,6
Mercury,	13,568
Lead,	11,352
Silver,	10,474
Biſmuth,	9,822
Nickel,	7,807
Cobalt,	7,811
Copper,	7,788
Iron,	7,6
Tin,	7,291
Zinc,	7,19
Manganeſe,	6,85
Antimony,	6,702

Uranium,

Uranium,	6,44
Arſenic,	5,763

The ſpecific gravity of molybdena, titanium, chrome and tellurium are not known.

26. The hardneſs of the metals varies frequently in thoſe which are ductile, becauſe their parts may be brought nearer together by different degrees of preſſure. It does not vary in thoſe which are brittle. It is often leſs than that of the ſtony foſſils, ſince theſe reduced to a powder grind their ſurfaces, and ſerve to poliſh the metals. It is therefore evident that this property does not follow denſity, and that it depends on the integrant particles, and not on their vicinity to each other. This property is eſtimated or determined by the manner and the difficulty of poliſhing the ductile metals, as well as by the effect of a blow on the brittle metals. By comparing them it is found that eight degrees of hardneſs may be exhibited by an arrangement of the metals, and that beginning with thoſe which poſſeſs the property in the higheſt degree we ſhall place,

In the firſt rank, iron and manganeſe,
In the ſecond, platina and nickel,
In the third, copper and biſmuth,
In the fourth, ſilver,
In the fifth, gold, zinc, and tungſten,
In the ſixth, tin and cobalt,
In the ſeventh, lead and antimony,

In the eighth, arſenic, the moſt brittle, in fact of the brittle metals.

Mercury being conſtantly fuſed, cannot be compared with reſpect to this property. The comparative hardneſs of titanium, uranium, molybdena and chrome is unknown.

27. The elaſticity in metals appears to follow the ſame order as the hardneſs.

28. Ductility, is one of the moſt important, and moſt uſeful phyſical properties of the metals, and belongs excluſively to theſe bodies. Its name is derived from the habitude of theſe bodies, to ſuffer themſelves to be led or drawn beneath the hammer, the preſſing-cylinder, or through the wire-plate. It is cauſed by the metallic particles, ſliding over each other without diminution of their adheſion, when this effect is produced by preſſure. A kind of variety is remarkable in the ductility of metals. Some in fact, are much more capable of being flattened than drawn out, as lead and tin, and others in the contrary ſtate as iron. It is thought, that this depends on the form of the particles, and the nature of their aggregation. The malleable, and laminable metals ſeem to be compoſed of ſmall plates, and the malleable metals of fibres placed one beſide the other. The one ſlide by their flat ſurfaces, the other lengthen, and adhere end to end. When the metals are compreſſed, caloric is expreſſed or driven out from between their particles, and

they become hot. The more theſe are condenſed, the more hard and elaſtic they become, with an increaſe of ſpecific gravity, at the ſame time that they become more ſtiff and brittle ſo that they crack, and are broken aſunder. This laſt property is denominated hammer-hardening. Ductility and ſoftneſs is reſtored to metals by heating them, and this operation when applied for the ſpecific purpoſe here mentioned is called annealing. Though we cannot really compare the ductility of metals excepting in thoſe which are not brittle, it will not be impertinent to aſſign reſpective rank to them in the order of this property, to determine the degrees of brittleneſs. Beginning by thoſe which are moſt ductile, and deſcending to the metals, which are the moſt brittle, the following arrangement muſt be admitted:

Gold,
Platina,
Silver,
Iron,
Tin,
Copper,
Lead,
Zinc,
Mercury,
Nickel,
Tungſten,
Biſmuth,
Cobalt,
Antimony,

Manganeſe,
Uranium,
Molybdena,
Titanium,
Chrome,
Arſenic.

It muſt be remarked, that the arrangement of the eleven laſt metals, all of which are brittle, is not as well determined, as that of the real ductility of the nine preceding; that nickel ſeems to approach ſomewhat near to the ſame ductility of zinc; that ſome authors even place it before this laſt with regard to that property, though I do not think them well founded in that aſſertion, and that the metals moſt recently known, molybdena, titanium, uranium and chrome, have not yet been ſufficiently examined, nor perhaps ſufficiently purified to admit of the order I have aſſigned to them, being conſidered as definitive.

29. The word denſity, expreſſes the coheſion of the metallic particles with each other. As this property is of great importance in the arts, it has long been meaſured by means of metallic wires of the ſame diameter, at the extremity of which, weights are ſuſpended untill the wires break. The wire is fixed by its ſuperior extremity, and drawn by the inferior to which the weights are attached.

We cannot eſtimate this force, but upon the ſeven metallic ſubſtances, which are capable

ble of being drawn into wire. They muſt be arranged in the following order:

Iron,
Copper,
Platina,
Silver,
Gold,
Tin,
Lead.

30. I give the appellation of conductibility to that property which metals poſſeſs, of ſuffering caloric to paſs rapidly between their particles, and conſequently to deprive other bodies ſpeedily of their heat, and to communicate it equally to thoſe which touch them when they themſelves are heated. Experiments of ſufficient accuracy have not been yet made reſpecting this property, to enable me to offer in this place, the relation which would preſent itſelf between the different metallic ſubſtances. It appears to follow a particular law in the metals, and is frequently in a proportion, if not oppoſite, at leaſt very different from that of the fuſibility.

31. The dilatability by caloric, ought to be ranked among the phyſical properties. It conſiſts only in the ſimple ſeparation of the particles of metal by thoſe of caloric which interpoſe, and accumulate themſelves between theſe particles, and at the ſame time diminiſh their adherence, and their attraction. As it does not alter the chemical properties of theſe bodies, and is in truth, only a phyſical action,

conſiſting only in a commencement of change of ſtate with regard to metallic ſubſtances; as this property poſſeſſes many uſeful relations to the arts in which metals are employed, and is of conſequence, that it ſhould be well known, it would be of very eſſential ſervice to the induſtry of man, if it were poſitively determined; but this has not yet been performed with the accuracy that might be wiſhed. We know that it is ſenſibly proportional in each metal to the augmentation of caloric between the limits of the graduation of our thermometers; but at the approach of ignition the dilatation follows a law, much more rapid than the elevation of temperature, becauſe the expanſive force of caloric being then only weakly balanced by the mutual attraction of the metallic particles, is almoſt totally employed in ſeparating the particles from each other. In order to eſtimate the dilatation of the metals, the ratio of this dilatation, according to one denomination, being given by the experiment for one degree of the thermometer, the fraction which repreſents this ratio, is multiplied by the number of degrees to which the temperature has been raiſed. This product muſt be ſquared, if the dilatation of ſurface be required, or cubed, if that of bulk be expected, and thoſe relative expanſions in a given magnitude of metal, may be eaſily applied to individual quantities in order to obtain the abſolute quantity of dilatation in any required inſtance.

32. Fuſibility, like the laſt mentioned property is truly of a phyſical nature, ſince it is nothing more than the effect of dilatation, carried to that degree in which the expanſive force of caloric prevails over the mutual attraction of the metallic parts, ſo as to admit them to move freely in every direction amongſt each other, and to yield to the ſlighteſt preſſure. We muſt not conſider it as a combination of caloric with the metals, becauſe the fuſion ceaſes when the caloric is diſengaged, and becauſe it is neceſſary, that the ſupply of caloric, ſhould be continually kept up in order that fuſion may take place. This property varies ſingularly in the metals, and each of them may be heated to very different degrees before they flow. As the temperature to which they riſe at the moment of fuſion, cannot always be meaſured or indicated by thermometers, it has been determined in the following table by Citizen Guyton, as well according to the graduation of Reaumur, as the pyrometric ſcale of Wedgwood. The want of fuſion in arſenic, which is more volatile than fuſible, could only be eſtimated by approximation, and thoſe of molybdena, tungſten, uranium titanium, and chrome, which are very difficult to fuſe in general, reſemble platina in this reſpect.

Fuſibility determined by the thermometer of Reaumur.	31	—	0	Mercury,
	0			Tellurium,
	168	+	0	Tin,
	205	+	0	Biſmuth,
	296	+	0	Zinc,
	345	+	0	Antimony.

Fuſibility determined by the pyrometer of Wedgwood.	27			Copper,
	28			Silver,
	32			Gold,
	130			Iron, nickel, cobalt,
	160	+	+	Platina, manganeſe.

33. Volatility is the conſequence, and as it were the extreme of fuſibility. When the particles being as far removed from each other by the expanſibility of caloric move freely amongſt each other, if ſtill more caloric be accumulated between them they ſeparate more, become fuſed in that ſubſtance, partake its elaſtic fluidity, and riſe in vapours which are condenſed in proportion as the caloric which is only interpoſed abandons them. We might imagine that this property ſhould obey the fuſibility; but though it has not yet been exactly eſtimated, we muſt not conſider the one property as regulating the other. It was formerly aſſerted, to be the character of the brittle metals or ſemi-metals to be volatile. We may obſerve, that arſenic, which is much more volatile than fuſible, occupies the ſecond rank in this reſpect after mercury; that biſmuth and antimony immediately follow; that tin

and lead ſo much more fuſible than the latter are yet volatile only with extreme difficulty, and that a ſtrong fire is required to volatilize copper, ſilver and gold, metals of a middle fuſibility as was formerly obſerved. An extreme heat is required to reduce iron, and the other leſs fuſible metals into vapour.

34. Cryſtallizability conſiſts in the tendency of the metallic particles when ſeparated from each other by their fluidity, to approach each other by ſurfaces beſt adapted, and to aſſume by their arrangement a regular form concerning which we have already treated in the ſecond Section of the preſent work. When the metals after fuſion are ſuffered to cool very ſlowly, and the congealed ſurface is broken, we find under the inner portion which ſtill remains fluid, after pouring the portion off, cryſtallizations of various degrees of regularity depending on the regular tetrahedron or cube, which is the form of their integrant particles. We ſhall obſerve the varieties which this double form produces in the hiſtory of each metal.

35. All the metals eminently poſſeſs the faculty of conducting electricity, in conſequence of which they are uſed in a multitude of electrical experiments. It appears that galvaniſm, or the property of exciting convulſive motions in the muſcles, by interpoſition of two different metals, brought near each other after having cauſed them to communicate with

the nerves which are diſtributed in the muſcles depends on their conducting quality, and that it is intimately related with electricity as Volta thinks he has proved. The electric fluid in this reſpect only follows in its progreſs, or its communication, a law ſomewhat different from thoſe which direct it among bodies not animated, and there ſtill remain diſcoveries to be made in metallic galvaniſm, conſidered under this point of view.

36. Odour, a property with which all bodies are endued, and which, being inherent in their nature, does not ſuppoſe with regard to men and other animals, who poſſeſs ſenſation, any other requiſite than the tranſpoſition of theſe bodies into their noſtrils, and contact with their olfactory nerves, is much more ſenſible in ſome metals than in others, for which reaſon, attempts have been made to characterize certain metals from this property. It muſt be remarked with regard to odour, that the metals which poſſeſs it, appear to be enveloped with an atmoſphere, which is truly a ſaturated ſolution of their particles; that the air carries a portion of this ſolution, and applies it to the ſurface of all bodies, and conſequently to the ſenſible membrane of the noſtrils, where it cauſes perception. It is alſo in this metallic atmoſphere which exiſts, even with regard to the metals ſuppoſed to have no odour, that the magnetic, electric, galvanic, and probably, many other phenomena more manifeſtly chemical,

take place, which ſeem to be with regard to ordinary chemical operations, the ſame as thoſe microcoſmic beings, of which modern diſcoveries have exhibited as it were a new world, bear to the natural beings, which fall under the ordinary obſervation of our ſenſes.

37. Taſte is alſo a very remarkable property of a great number of metallic ſubſtances. Three metals only are exempt, namely, ſilver, gold, and platina, and this was one of the reaſons which cauſed them formerly to be regarded as more perfect than the others. Every one knows the taſte of copper, of iron, of tin, and of lead. Phyſicians carefully obſerve the taſtes of zinc, of mercury, of antimony, of arſenic, of biſmuth, and they know that this property accompanies, and even deſignates the active properties of theſe metals on the animal economy. Though this taſte be really peculiar to each metal, it has nevertheleſs, in all of them, a general character which has been called metallic taſte. It is a kind of hard, acrid, ſlight ſtyptic taſte, more or leſs evident, but always diſagreeable, which excites ſpitting, and announces a deſtructive character. This property is ſtill more ſtrong and powerful in various combinations, and particularly in metallic ſolutions and ſalts, as we ſhall hereafter ſee.

SECTION IV.

Concerning the Natural Hiſtory of the Metals.

38. NATURE preſents the metallic ſubſtances on the ſurface or in the interior of the globe. They are either alone or combined with different matters. Theſe laſt combinations are called ores. They are depoſited in beds more or leſs continuous between the beds of ſtones and earthy ſalts, where they form what is called veins. The part which covers them is called the roof, that which ſupports them the floor, and the collection of ſtones or cryſtals which accompany ores, conſtitutes their gangue or matrix.

39. Veins are diſtinguiſhed into rich or poor, head veins or ſprigs, true veins or croſs veins. The terms rich and poor applied to the veins of ores explain themſelves; the head veins are in large maſſes, which will pay well for the working; the ſmalls veins are ſcattered or diſperſed and do not deſerve working. They are only followed occaſionally, in order to find the head vein from which they branch. Direct veins are thoſe which follow the ſame direction, and may be eaſily purſued. Croſs veins are thoſe which are interrupted or broken, and ſeem to loſe their continuity.

40. The name of ores ſuppoſes the metals to be combined with ſome foreign ſubſtances which marks their properties, and has been denominated the mineralizer. For the ſame reaſon, metals in this ſtate are ſaid to be mineralized. It often happens that two or more metals are united at the ſame time to the ſame mineralizer; and frequently, one ſingle metal is at the ſame time combined with various mineralizers, and ſtill more frequently are there in ores, all together a number of metals and mineralizers.

41. The metals and their ores are uſually found in ancient primitive mountains of granite, gneis, quartz, between the beds of which their veins flow either in horizontal, oblique, or inclined directions. The latter is the moſt frequent: ſo that the head of the vein almoſt always appears out of the earth, or to the day, and by that means gives a certain indication of its preſence. The pretended bad ſtate of the trees, the dryneſs and want of vigour in plants, the hard and dry ſands are but uncertain indications of ores. The pretended inclinations and rotations of branches of trees ſupported on the fingers, and which are called divining-rods are mere tricks of knavery and quackery, as are likewiſe the tremblings, convulſions, and indiſpoſitions pretended to be ſuffered by certain men who in that manner impoſe upon human credulity. The coloured and metallic ſands, fragments of the ores attached to mountains, rolled down in

the plains, waters charged with certain metallic ſalts, and laſtly, the boring inſtrument, are the only ſure indications, which deſerve the confidence of thoſe who ſearch after metallic bodies.

42. Beſides the ores of original formation concealed in the bowels of mountains, and which, croſſing them in veins, ſeem to have been poured at one ſingle caſt at the very time of the formation of theſe mountains, we find ſome minerals depoſited in ſecondary ſtrata, in maſſes, in ſtalactites, incruſtations, cryſtals, in mountains or hills of modern formation, where they fill ſubterraneous clefts and cavities. Theſe are manifeſtly owing to the operation of water, and the tranſport of matters altered, diſſolved, modified in their paſſage. The oxigen of the former veins is not ſo well underſtood, though it is alſo attributed to water.

43. The numerous diſcoveries which have been made in the laſt half century reſpecting the nature of ores, and the ſeveral moſt modern analyſes which have much enlightened and ſimplified our knowledge, reſpecting which, there were ſtill many errors and hypotheſes before the later labours of Bergmann, Klaproth, and Vauquelin, permit us at preſent to claſs theſe natural productions, or to reduce the various ſtates of foſſils to five claſſes, namely,

a. Native metals,
b. Metals alloyed together,
c. Metals united with combuſtible bodies,

d. Oxided metals.

e. And laſtly, metallic oxides combined with the acids

44. The ridiculous name of virgin metal was formerly given to thoſe which are at preſent more accurately called native metals. This firſt claſs includes metallic ſubſtances which are found in the earth, in poſſeſſion of all their characteriſtic properties, brilliancy, colour, form, weight, ductility, &c. Platina, gold, ſilver, copper, mercury, biſmuth, antimony, and arſenic, are frequently found in this ſtate, iron more ſeldom, and tin, lead, zinc, &c. ſtill more ſeldom. To this claſs are referred thoſe metals which in their native ſtate are alloyed only with ſmall quantities of other metals, ſo as to occaſion very little alteration in their obvious properties.

45. Metals alloyed together without any other combination, and without union with combuſtible bodies, are much more ſcarce in nature than might be imagined. Gold and ſilver, gold and copper, mercury and ſilver, are only found in this ſtate.

46. The natural combinations of metals with combuſtible bodies, are on the contrary, much more numerous and more multiplied. We might even ſay that it is in this ſtate, particularly in that of metallic ſulphurets, that nature has created them. Theſe ſulphureous compounds form the veins of ores, or thoſe continued maſſes with which the mountains are interſected. Theſe

veins are moſt commonly explored by man, and from theſe, the greateſt quantity of the metals uſed in ſociety, are obtained. Such, more eſpecially, are the ores of lead, copper, ſilver, zinc, mercury, antimony, &c. It is not improbable, but that other combuſtible bodies, carbon, and particularly phoſphorus, may be diſcovered as mineralizers of metallic ſubſtances.

47. The metallic oxides are alſo very abundantly ſpread over the face of the globe. But they are never found in ſuch large maſſes as the ſulphurets: they have long been conſidered as metallic earths, becauſe they have an earthy appearance. They are the product of the primitive veins penetrated, carried off, and tranſported by water; and are found in mountains of ſecondary formation. The oxides are uſually rich in metal, and eaſy to be treated. In this ſtate more eſpecially are found copper, iron, lead, zinc, antimony, and all the brittle metals. Platina, gold, and ſilver are the only metals which are not found native in this form.

48. Laſtly, the ſaline metallic combinations, or compounds formed of metallic oxides, united with acids or the ſimple radical, likewiſe form, if not the moſt abundant ores, at leaſt, thoſe which nature preſents moſt frequently, and in the moſt various ſtates. Native ſulphates and carbonates, of copper, of iron, of lead, of zinc, the muriates of moſt of theſe metals, and of mercury, the phoſphates of lead and of iron, the arſeniates,

the molybdates, the tungſtates, and the chromates of metals are all found in the native ſtate. Theſe laſt four are particularly formed by the oxides of the brittle metals: ſometimes in beds, in depoſitions, in ſtalactites, in incruſtations. Sometimes they cryſtallize in ſubterraneous cavities; frequently, they are diſſolved in water, but they are never found in maſſes like the ſulphurets.

49. The value of metals in commerce, and the profit they afford to thoſe who poſſeſs them, proportioned to the rank which they occupy in the eſtimation of man, have frequently cauſed names to be given to ores which very inaccurately repreſent their true nature. Thus it is, that the denomination of ores of gold and ſilver, or of copper is given to ſuch ores as really belong to other metals, with reſpect to the proportion of metallic matter they contain, though they afford a ſufficient quantity of gold, ſilver, or copper to defray the expences of working with advantage.

50. This mode of denomination has cauſed much trouble and confuſion in mineralogy, and, though ſeveral authors have in this reſpect, adopted the nomenclature of the miners who conſider only the value of the product, and not the proportions of the component parts, it is evident, that mineralogiſts ought to follow a contrary courſe, and refer each ore to the metal which it moſt abundantly contains; for it very often happens, that minerals contain five or ſix

different metals, united at the ſame time to one or more mineralizers.

51. There are conſequently, three different manners of diſtinguiſhing and claſſing metallic ores. One, that of miners, which has reſpect only to the precious metal which is afforded. This is not the method, but ſimply the uſage of workmen who expreſs the aim of their labours, or the end towards which they are directed. It cannot but be hurtful to the progreſs of ſcience, when applied as the language of claſſification. The ſecond conſiſts in referring each ore to the metal with which it is the moſt charged, and conſequently, to follow in their claſſification and diſtribution the ſeries of the metals. We ſhall make uſe of this method in the hiſtory of each metal. The third, by conſidering the ores almoſt abſtractedly from the metals with which they may be loaded, and conſidering them only as natural compounds, diſpoſes or arranges thoſe according to the number and the proportion of their principles. This general and truly mineralogical method may ſerve to claſs regularly the mineral productions of nature. A ſketch will be preſented in the ſection next following the preſent.

SECTION V.

Concerning the Art of Aſſaying Ores or Docimaſy.

52. BY ſucceſſive labors in the art of aſſaying ores, or the analyſis of the natural combinations of metals with the different ſubſtances which mineralize them, we have ſucceeded in diſtinguiſhing theſe compounds, in claſſing them, and in referring them to the metals to which each belongs. Without this art, no phyſical property or apparent character could have guided men to this diſtinction, and the knowledge of ores would have remained in that ſtate of uncertainty, error and imbecility in which it ſo long languiſhed before the reſearches of modern chemiſts.

53. Ores were at firſt aſſayed with the ſimple view of aſcertaining the advantage which might be derived from them, the nature and quantity of metallic ſubſtances which might be expected, and to guide miners in the works they might undertake, and devote to the exploring each kind of ore. This intention was not in the early times directed to the accurate analyſis of minerals, or to aſcertain with preciſion the nature or order of their component parts. The only views which at firſt animated chemiſts, were to aſcertain the proportion of metal they

tained, the facility and difficulty of extracting it, and to compute the loſs and charge which that operation might require. Thus far the docimaſtic art was confined to the ſimple practice of the miners. But ſkilful chemiſts having been frequently conſulted reſpecting this art, and the great varieties obſerved in different modifications of the ſame metal, having ſtruck thoſe who were charged with their examination, the docimaſtic art ſoon advanced towards perfection, and has become one of the moſt important branches of chemiſtry. Its reſults are no longer confined to the mere metallic products; they are extended to the different matters which mineralize metals, their proportion, their adheſion, their attractions, and their various modifications or habitudes.

54. The art, therefore, being elevated to new conceptions, became connected with mineralogical ſcience. It is an eſſential part of this branch of natural hiſtory, to which it has given a great degree of perfection. We are led, therefore, to diſtinguiſh docimaſy into two parts, the one which is directed merely to enlighten metallurgy, ſo as to precede and direct its proceſſes; and the other, which conſiders its ſubject in a greater extent, and not only applies to the reſearch of the metal, and the means of extracting it with the leaſt trouble or charge, but alſo propoſes to determine with accuracy the materials of the ores, to compare them together, and to furniſh the means of ſyſtematically

arranging them. The aim of the firſt is to direct metallurgic practice; the other while it anſwers the ſame purpoſe, is alſo advantageous to the mineralogiſt who is deſirous of claſſing metalliferous foſſils, and the geologiſt who deſires to know their formation, their changes, their tranſitions, and reſpective relations in nature. The chemiſt muſt conſider docimaſy in this double point of view, in order to form a proper conception of the properties of metals.

55. Though the docimaſtic works in general may be conſidered as really different, according to the ores upon which they are employed, they neverthelefs, have one common reſemblance under which we may conſider the proceſs as an operation nearly analogous with all minerals, at leaſt, as far as relates to the art of the miner. The ſpecimens of the ore are firſt ſelected out of the rich, the poor, and the middling ſamples: this is called lotting it. Theſe are pulverized, are broken in a wooden ſtamper, to deprive them of their light ſtony matrix, and collect the mineral at the bottom of the veſſel. They are roaſted in a ſhallow earthen veſſel, with a proper cover to prevent loſs by decrepitation; by this treatment, the volatile part of the mineralizer flies off in vapour in the atmoſphere, and the metallic part becomes oxided. The ore is left ignited till it emits no more perceptible vapour. The weight after this roaſting, ſhows the proportion of volatile matter it contains. The roaſted ore is afterwards mixed with three times

its weight of black flux or tartar, half burned by nitre, and a ſmall quantity of muriate of ſoda. The carbon of the flux thus oxides the metal. The alkali cauſes the matrix to flow, and the ſea-ſalt covers the metallic ſubſtance, and defends it from oxidation. When the fuſion is complete, the mixture is ſuffered to cool, after which, under a well-fuſed and very homogeneous ſcoria, the metal is found collected in a ſingle maſs, of which the weight and the nature indicates what may be expected by metallurgic work in the large way.

56. The aſſay often requires to be modified in certain reſpects according to the different nature of the ore.

In ſome caſes, more active fluxes than the black flux are required, particularly for the more refractory or more infuſible ores. In that caſe, borax or pounded glaſs with pot-aſh is taken, and frequently, oil or tallow is added to favor the reduction of the metallic oxides. Sometimes, even the elective attractions are employed to unmineralize the metal by heating the ore with another metal, which has a ſtronger attraction for ſulphur than that metal has which is contained in the ore. But it ſeldom happens in caſes of this ſort, that a portion of the metal employed does not combine with that which was added, ſo as to alter its quantity and quality.

57. The metal obtained by this firſt proceſs is ſeldom pure. A metal difficult to burn, ſuch

as was formerly called a perfect metal, frequently contains a very oxidable, or as it was called, imperfect metal. In that caſe, to abſtract this laſt, the metal is roaſted a ſecond time, heating and agitating it with the contact of air; and though this proceſs has not an extreme accuracy, it is ſufficient, nevertheleſs, to afford a reſult ſuitable to the expectations of miners. This method of aſſaying is even too accurate, in ſome inſtances, for the neceſſities of metallurgy; for it gives a greater metallic product than can be hoped for in the large way, and produces an error, becauſe it requires the uſe, and is made under the influence of fluxes which cannot be applied in the operations in the large way: for this reaſon, the aſſay is made to reſemble the metallurgic works more cloſely by attempting to flux the ores ſimply among charcoal, and the fuſion is aſſiſted by iron ſcales, or glaſs gall; matters of ſuch low price that they can be employed in the large way.

58. Though the aſſay may be ſufficient for the miner or metallurgiſt, thoſe who cultivate mineralogy and chemiſtry are not content with it, becauſe it does not afford the information they require for the knowledge and claſſification of minerals. Part of the metal eſcapes in vapour, part remains in the ſcoria; the metal itſelf is more or leſs impure, and its ore is diſſipated or confounded in the ſcoria. To this irregular aſſay, we muſt, therefore, ſubſtitute an analyſis, accurate in all the means which art

can employ. The imperfect roaſting of the metallurgiſt muſt give place to the regular diſtillation with the retort, or the action of fire encloſed in veſſels in ſuch a manner as to collect the ſolid; the liquid or aeriform products, diſengaged by caloric, to aſcertain their nature and determine their quantity, at the ſame time, that a proper eſtimate is made of the fuſibility of the ore, after having carefully deſcribed its form, ſtructure, colour, ſpecific gravity, and all its phyſical properties.

59. The moſt ſevere and moſt uſeful method of analyſing ores, or to make a complete chemical aſſay, conſiſts, more eſpecially, in treating them by acids which diſſolve the metals without touching the mineralizer, particularly ſulphur. For this purpoſe, however, we muſt uſe the ſulphuric or muriatic acids, for the nitric, particularly when too ſtrong, forms a ſulphur, and produces error reſpecting its quantity, and even frequently changes the nature of the ore. The ſulphuric or muriatic acids muſt alſo be diluted in almoſt every caſe. The inſoluble matters being well waſhed, indicate the proportion, as well as the nature of the mineralized ſubſtance. The metal in ſolution is precipitated by alkalis, by hydro-ſulphurated water, and often by other metals, which having a ſtronger attraction for oxigen, diſoxide it, and ſeparate it from the acids, in which they take its place. In general, it is eaſy to obſerve, that in this kind of analyſis, which is here pointed out only

in a general way, an extenſive and entire knowledge of the action of all bodies on the ſeveral metals, is ſuppoſed to be in poſſeſſion of the operator. For all bodies, when once their action is well known, may become very uſeful inſtruments in the analyſis of ores. Numerous proofs of this will be ſeen in the hiſtory of each particular metal.

SECTION VI.

Concerning Metallic Works on a large Scale, or Metallurgy.

60. WHEN it is once aſcertained by the docimaſtic effect, that an ore may be worked with advantage, the metallurgiſt proceeds in his operations, firſt extracting the ore by all the mechanical methods the art poſſeſſes, which conſiſt in digging ſhafts, opening adits, employing various machines to raiſe the water, renew the air, bring up the ore, favor the aſcent and deſcent of the miner, prevent the earth from giving way, &c.

61. Theſe firſt proceſſes of the extraction of the ore, enlightened by the information of geometry, mechanics, mineralogy, geology, ſubterranean geometry, founded alſo on the knowledge of conſtructions of frame-work in wood, requiring the united exertions of various talents, and ſupported by courage, patience, and firmneſs

in enterprize, conſtitute a very important art which requires long and ſerious ſtudy, continual obſervation, experience, and practice, added to the moſt profound theoretic meditations. A man thus qualified is an engineer of mines. Though, this art may appear foreign to the general ſtudy of chemiſtry, it is neceſſary that the ſtudent ſhould be acquainted with its firſt notions or elementary parts, which neceſſarily precede the knowledge of the metallic treatment of ores. The following are the baſes of the art of extracting them from the earth :

62. In general, after having bored the ground which contains ores, or having aſcertained their exiſtence by various indications, a ſquare perpendicular well, or ſhaft is dug in the ground, ſufficiently wide to place ſtrait ladders therein ; over which machinery is fixed for the purpoſe of raiſing and lowering veſſels, and in which it is ſometimes neceſſary to fix pumps to draw off the water which is collected. If the ore be too deep for a ſingle ſhaft to lead from the graſs or ſurface, to the vein at the bottom of the firſt ſhaft, an horizontal gallery is opened, at the end of which a ſecond ſhaft is ſunk, and in this manner the workmen proceed until they arrive at the bottom of the mine.

63. When the rock to be perforated is hard, ſolid, and capable of ſupporting itſelf, the ſhaft will not require to be guarded within, but if it be ſoft and friable, if it threaten to

fall in during the excavation, it becomes neceſſary to ſupport the ſhaft and gallery with pieces of wood-work, covered with planks all round, in order to ſupport the earth and retain the fragments, which from time to time would ſeparate and might maim the workmen.

64. One of the important particulars of the art of exploring mines, is the renovation of the air. When it is practicable to open a gallery which ſhall lead from the bottom of the ſhaft to the day or open air, a current is eaſily eſtabliſhed by this ſimple artifice. When this is not poſſible a ſecond ſhaft is ſunk to the extremity of the gallery, oppoſite to that where the firſt was ſunk. When one of theſe ſhafts opens at a different level from the other, the circulation and renewal of the air are eaſy. If the ſecond ſhafts be of equal height, the current will not take place ſpontaneouſly, but muſt be determined by cauſing of them to communicate with a lighted furnace.

65. The danger of waters which overflow the works, and retard the operations, at the ſame time that they threaten the ſafety of the workmen, are no leſs neceſſary to be provided againſt. If the water tranſudes gradually through the earth, it may be let off into the plain or the neareſt river by means of an horizontal adit. If it be collected in greater quantity, or if it be not poſſible to open ſuch an adit, the wa-is extracted by pumps, which are moved either by a ſtream, or by a pond, or by vapour of

water introduced, and condenſed in cylinders. Theſe laſt machines called ſteam-engines, are at preſent much more common than formerly. It is an object of great difficulty ſometimes to defend the works againſt enormous maſſes of water which ruſh forth when in digging a vaſt ſubterranean reſervoir is opened. Theſe caſes happily are very rare, but they are in ſome meaſure provided againſt by a kind of movable ſtrong door, or barricado, which the workmen place at the moment when they find by the particular ſound of the rock, that the waters are coming in upon them, which barricado, by ſeparating them from the liquid, gives them time to ſave themſelves.

66. The deſtructive elaſtic fluids, which ſo frequently are diſengaged in the cavities of mines, and particularly the carbonic acid gas, and different ſpecies of mixed hidrogen gaſſes, more or leſs pernicious, are alſo among the moſt formidable enemies of miners. Galleries, fires, ventilators, inflammations by means of torches held at a great diſtance in thoſe parts of the mines which are mephitized by the inflammable gaſſes, and particularly the various methods of cauſing freſh air to enter, are the only remedies which can be oppoſed to theſe ſubterraneous evils.

67. When the ore which has been diſcovered and extracted from the ground by pick-axes, crows, gun-powder, &c. is carried to graſs, it is ſubjected to all the mechanical and chemi-

cal operations requiſite to ſeparate the metal. Theſe operations neceſſarily conſiſt in ſorting, ſtamping, waſhing, roaſting, fuſing and refining. Though each of theſe ſix metallurgic operations, differ more or leſs according to the nature and kind of the ore, they are nevertheleſs all more or leſs neceſſary to each other, and they have in every ſpecies and locality, and under every variety of manipulation always ſome common circumſtances which allow them to be deſcribed in a general manner.

68. Sorting conſiſts in the ſeparation which is made after the ore is brought to graſs, or to the ſurface of the ground, of the different pieces of ore, which frequently require different modes of treatment, or are expected to afford different products according to their riches and their nature. It is not practiſed excepting in rich and valuable ores, ſuch as thoſe of gold, ſilver, &c. It is entruſted to a ſkilful workman, or men well experienced in mine works, one of the maſter miners.

69. When the ore is ſorted, it is carried to the ſtamper. This is an inſtrument for pounding, a kind of large mortar or trough, in which, by means of wells, vertical pieces of wood are moved up and down, terminating below in an iron ſurface rounded like the end of a peſtle. The alternate riſe and fall of theſe kind of peſtles moved by water, air, or fire, break, and pound the ore, together with its gangue.

70. From the ſtamping mill, the pounded ore is conveyed to the waſhing, which is performed by many different operations, either by hand in wooden veſſels, or in troughs, which croſs a current of water, or on the bank of a brook, or even in its bed, or upon inclined tables armed with cloth, intended to ſtop the irregular fragments of the ore; this laſt machine is not uſed, excepting when the ore is rich and valuable for the abundance of its metal. In all theſe proceſſes, the agitated water carries with it the ſtony matter which is lighter than the ore, while the ore itſelf falls to the bottom of the utenſil in which the waſhing is performed.

71. The operation of roaſting renders the ore friable, divides it and reduces into ſmall pieces, or ſeparates by volatilization the greateſt part of the mineralizer, which conceals the properties of the metal. It is performed in a variety of ways or different proceſſes, according to the nature of the ore, the force or extent of fire intended to be applied, the degree of adheſion, and quantity of mineralizer, whether ſulphur or arſenic, and ſometime both together, which are intended to be ſeparated. The roaſting is ſometimes performed in the air, ſometimes in furnaces, or among the charcoal; in ſome inſtances there are particular furnaces for this operation, and in others the ſame furnaces as are intended for ſmelting, are alſo uſed for roaſting.

72. Smelting, or the art of fuſing the ores after roaſting, is the principal and moſt important of metallurgic operations, all the other being preliminary or preparative to this. The whole attention of the miner is directed towards this proceſs; to this all his efforts are applied, becauſe it affords the true uſeful product to which his hopes are directed. Though it conſiſts in general in fuſing the roaſted ore to extract the metal; though in this point of view it ſeems to preſent a ſimple and uniform operation, there is, nevertheleſs, no operation which differs ſo much in its circumſtances, according to the nature of the metal and the ore required to be treated, and according to the furnaces made uſe of, the nature and quantity of the combuſtible employed, the energy, duration, and adminiſtration of the fire, the addition of an appropriate flux, the heat being applied in the midſt of the coal, or in crucibles, the period, the length of time, and the mode of caſting the fuſed metal; every thing, even the form of the metal which flows out, varies, and preſents to the obſerver very remarkable differences. On this ſubject we ſhall ſpeak more largely under the hiſtory of each particular metal.

73. When the ore is ſmelted, and the metal obtained, the whole proceſs is not yet finiſhed. This metal is ſcarcely ever pure. It is either altered by certain ſubſtances foreign to its metallic nature, or it contains a portion of another

metal, which alters the properties of this which is deſired in a pure ſtate; or elſe it contains a portion of a metal more valuable than all the reſt of the maſs, which it is neceſſary therefore to extract; or, laſtly, it is an alloy, in large proportions of ſeveral metals, which are required to be ſeparated from each other. Theſe various objects to be fulfilled, of which the practice muſt differ, as we perceive from the ſimple enumeration, belong to the laſt operation of treating ores in the large way. All the operations ſubſequent to the ſmelting, are comprehended under the general name of refining, becauſe the effect is always to obtain a pure metal. Under each article of the ſeveral metals we ſhall ſhow what are the practices reſpectively for refining the ſame.

SECTION VII.

Concerning the Oxidability, or Combuſtibility of the Metals by the Air.

74. ALL that has hitherto been ſaid reſpecting the metals in general, is but remotely applicable to their chemical properties, or at leaſt it requires the ſtudy of theſe laſt properties, in order to receive a more accurate development, and to preſent the moſt preciſe reſults to the underſtanding. It is therefore eſſential to fix our attention upon theſe laſt properties in order to obtain the characters of metallic ſubſtances.

The ſix laſt paragraphs of this hiſtory of the metallic genus are conſecrated to the examination of theſe properties. We paſs ſucceſſively in review the manner in which they are altered by the air, their combination with combuſtible bodies, their action upon water and the oxides in general, that which they exerciſe upon the acids, their habitudes with ſalifiable baſes, and laſtly, with the ſalts. Theſe ſix diviſions will complete all that can be known reſpecting the chemical compoſitions of the metals; and we ſhall ſee that the ſame order, followed with ſome modification with regard to the ſpecies, will render their hiſtory equally accurate and complete.

75. When we ſeparate the oxidability of metals by the air, or their combuſtibility, properly ſo called, from all their other chemical properties, we announce that this property deſerves a moſt marked attention. It is in fact the moſt prominent fundamental character, the moſt important attribute of the metals; it is at the ſame time the key for explaining all the phenomena they preſent in their combinations. The oxidability of theſe bodies by the air, varies not only with regard to their ſpecies, as we ſhall ſee in the hiſtory of them reſpectively; but they alſo vary,

A. With regard to the temperature at which the combuſtion is effected.

B. Or the facility with which it takes place.

C. Or the difference which the temperature itſelf undergoes during the proceſs.

D. Or by the proportion of oxigen it requires.

E. Or the phenomena which accompany it.

F. Or the various attractions of the oxiding principle to the metals.

G. Or the ſtate of the oxigen in the oxided metals.

H. Or, laſtly, by the character which the metallic oxides aſſume in proportion as they acquire that ſtate. In order to obtain accurate notions of theſe circumſtances we muſt conſider each of them by itſelf.

76. The oxidability of certain metals by means of the air, commences at the loweſt temperature, but in other metals it requires the moſt extreme heat. Manganeſe, and iron, for example, burn at all temperatures; ſilver, gold, and platina, on the contrary, do not burn unleſs extremely heated. All the other metals hold an intermediate place between theſe two extremities. On this account it is that the oxidation of metals, being formerly conſidered as a kind of deſtruction, becauſe in this proceſs they loſe their metallic properties, and undergo a great diminution with regard to the arts, chemiſts have conſidered gold and ſilver as indeſtructible metals, and iron, on the contrary, as the moſt deſtructible of theſe ſubſtances. But it is evident, that this is only a ſpecific difference between them, that it truly relates to the time proportionally required for their oxidation. For there is not a ſingle metal which, when expoſed

for a ſufficient time to the air, does not at laſt undergo combuſtion by the mere temperature of the atmoſphere.

77. The facility of oxidation is the conſequence of the preceding property. Some metals burn, and become oxided ſo eaſily, that it is neceſſary to defend them from the contact of the air, if we wiſh to preſerve their brilliancy and their ſolidity. Such are iron, tin, lead, copper, mangaueſe, which cannot be well defended from change by the air but by covering them with a varniſh or a metallic coating of ſome other kind. On the contrary there are metals which undergo ſcarcely any change, even in their poliſh, ſuch as gold and platina.

78. The metals differ in their oxidability, not only with regard to the manner in which they reſpectively demand an elevation of temperature, but there is with regard to moſt of them, a diverſity even in the mode of their oxidation by which the difference of temperature they are expoſed to may be marked. In general, they all tend to become oxided more eaſily on the one part, and to abſorb their oxigen on the other, the higher the temperature is to which they are expoſed. And ſtill more do moſt of the metals become oxided in a determinate manner, and at any determinate temperature, whence we may appreciate the ſtate of their oxidation by the heat which has been communicated to them.

The elevation of temperature in the metals almoſt always cauſes rapidity of oxidation, and elevates this property even to inflammation, or the evident phenomenon of combuſtion. Thus it is that when fine filings of the metals are thrown into a ſtove in a ſtrong ſtate of ignition, or through brilliant flames, they form, while burning, ſparkles of a lively and ſhining appearance, depending on the ſtrong heat they undergo; and from the ſame cauſe it is that iron or ſteel, ſtrongly ſtruck againſt ſiliceous ſtones, burns with a lively flame in the air, in conſequence of the great heat which this percuſſion communicates to them.

79. The proportion of oxigen which unites to the metals during their oxidation, is alſo one of the circumſtances which cauſe the variation of this phenomenon. They all differ with regard to this proportion, and, conſequently, demand a greater or leſs contact of the air, in order that they may be burned. Each metal likewiſe varies in itſelf as to the quantity of oxigen it abſorbs in the air, according to the manner in which the combuſtion is performed, and the temperature to which it is raiſed.

80. In all the limits of the condition and circumſtances which have been here mentioned, the phenomena of the oxidation of the metals are different. Sometimes the metal ignites and takes fire; ſometimes it is oxided without fuſion, or, in other inſtances, the metal does not oxide until after it has been fluid. Sometimes it

becomes covered with a thin brittle cruſt or adherent powder; in other inſtances a pellicle of rainbow colours is formed at its ſurface to which the oxide does not adhere. But in every caſe the metal becomes tarniſhed, loſes its brilliancy and its colour, and aſſumes an appearance which announces the oxidation it has undergone.

81. Oxigen, by mixing in the metals in proportion as they burn by expoſure to the air, either contracts an adherence, or unites with an attraction which is peculiar to each of them, and of which the degree is highly important to be known with regard to a multitude of operations and chemical reſults. On this degree depends the difficulty of ſeparating the oxigen united to the metals, and the neceſſity of ſometimes employing bodies which attract it ſtill ſtronger in order to cauſe its ſeparation.

82. We muſt alſo obſerve, during the fixation of atmoſpheric oxigen in metallic ſubſtances, the mode alſo of this fixation, and the ſtate which the principle itſelf acquires. In ſome of the metals it is abſorbed in a very ſolid ſtate and loſes much caloric; in others it is precipitated without abandoning the ſame quantity of its ſolvent; ſo that if the ſeveral metals be oxided ſingly in the centre of the calorimeter, the quantity of fuſed ice may ſerve to determine the proportion of caloric diſengaged from the air by each of them; and, conſequently, the ſtate of ſolidity which the oxigen contracts. This proportion

anſwers to the manner in which their decompoſition or diſoxidation may be effected, thoſe which have abſorbed oxigen in the leaſt ſolid ſtate, or retaining the greateſt quantity of caloric, are reduced eaſily by caloric or by light; thoſe on the contrary, in which the oxigen fixes itſelf with the loſs of much of its ſolvent, are not unburned or diſoxided, or conſequently reduced into the metallic ſtate, but by a great accumulation of caloric. Moſt of the metals even require the addition of ſome other body which has a ſtronger attraction for oxigen than the metal itſelf has.

83. With regard to the characters which diſtinguiſh the metallic oxides made by the contact of the air, they are all varied in the different ſpecies, as we ſhall hereafter ſee; but they have at the ſame time certain properties common to all of them, by which they differ from the metals; and it is to theſe properties that we muſt in this place direct our attention. All the oxides poſſeſs the pulverulent form, or they are brittle, and eaſy to be reduced into powder. They preſent all the poſſible ſhades of colour, from white and grey to brown and deep red; they weigh more than the metals from which they are produced, and this augmentation amounts to a few hundredth parts in ſome oxides, and in others to more than half their weight; they reſemble earths, and for this reaſon they were formerly denominated earths, or metallic calces. Some of them reſume their metallic

ſtate by the mere contact of light, or caloric; others, without paſſing entirely to that ſtate, approach towards it; others require the addition of carbon ignited by fire, which attracts their oxiding principle; and there are ſome which ſeem to be incapable of reduction. Some of the oxides are fuſible by fire, and afford gaſes more or leſs coloured, tranſparent, and ſerve even as fluxes to the earths; others, on the contrary, reſiſt the moſt violent heat, and even injure the tranſparence of thoſe glaſſes into which they enter as component parts. Some of the oxides are volatile, but moſt of them are fixed. Some of them exhibit an acrid and cauſtic taſte, a ſolubility differing in degree in water, and even an acid quality; others have no taſte or ſolubility. Some of the calces unite with alkalis like acids, but the greater number are ſoluble in acids, and ſaturate them after the manner of the earthy and alkaline baſes. Some of them burn combuſtible bodies with flame, becauſe they contain oxigen in a ſtate ſlightly condenſed; moſt of them, on the contrary, burn ſlowly, and without any appearance of inflammation.

SECTION VIII.

Concerning the Combinations of the Metals with Combuſtible Bodies.

84. IN the ſecond ſection of this work, mention has already been made of the union of metallic ſubſtances with combuſtible bodies. We ſhall therefore in this place only repeat a few of the general circumſtances relative to theſe combinations, in order to render the hiſtory of the metals complete; and we ſhall inſiſt upon ſome which have not yet been pointed out, or have been too rapidly ſtated, or ſuch as were ſtated only for the purpoſe of placing the metals among the ſeries of undecompoſed combuſtible bodies, and comparing them to thoſe which had before been treated of.

85. We have ſeen that the union of azote, hidrogen, diamond, and the metals, is not yet known. It is not, however, improbable, that theſe combinations exiſt; and that though they have not yet been found in nature, nor produced by art, this circumſtance ariſes from the proceſſes of chemical analyſes and ſyntheſes being ſtill very far from the ſtate of perfection neceſſary to form or to diſcover ſuch compounds. We know, however, that hidrogen gas is capable of holding ſeveral metallic ſubſtances in ſolution, particularly arſenic, zinc, and iron. It has been diſcovered that the diamond combines very well with iron by fuſion,

and converts it into ſteel; an effect which ſhows a ſtill ſtronger reſemblance of this combuſtible with pure carbon.

86. Though we are yet acquainted with only one combination of carbon, with a metal, we cannot doubt but that there muſt exiſt many others, and that moſt metallic ſubſtances are capable of uniting with this combuſtible ſubſtance. Nature probably forms theſe combinations, and the ſingular properties preſented by iron in its union with carbon, prove there are many diſcoveries ſtill to be made upon this object, which is of ſo great importance to mineralogy, geology, and all the arts relating to the metals.

87. Though we are unacquainted with any carbonated metals, or metallic carbonates excepting that of iron, we at leaſt have known for a long time, that the metallic oxides univerſally undergo a more or leſs evident decompoſition by carbon. This body ſeizes the oxigen of their oxides, burns either with flame, as happens with the red oxide of mercury at an elevated temperature, or ſlowly without flame. Carbonic acid is diſengaged in the form of gas during this proceſs and the metal is left in its metallic ſtate. We can even determine by this decompoſition, the proportion of oxigen contained in the oxides reſpectively, from the quantity of this acid obtained, and we can proportion with conſiderable accuracy the matters neceſſary for the complete reduction

of a mixture of carbon and metallic oxide to the double ſtate of metal and carbonic acid without reſidue. The ſucceſs of this laſt reſult obtained by Lavoiſier, ſuppoſes that we ſhould be well acquainted with the nature of the oxide, and the quantity of the oxigen which it contains; a portion of knowledge which is acquired by a previous operation in which we form an eſtimate of the quantity of carbonic acid afforded during the reduction.

88. The compounds denominated metallic phoſphorets were formerly unknown. Pelletier obtained them with great facility by reducing the vitreous phoſphoric acid mixed with the metals and charcoal, and it is alſo obtained by treating the metallic phoſphates, with charcoal and a ſtrong heat. I have elſewhere obſerved, that theſe compounds of which I ſuſpect the exiſtence in nature, though no experiment has yet exhibited them to chemiſts are but very ſlightly combuſtible in the air; that they are of a granulated texture with a brilliant metallic aſpect; that they are brittle, fuſible, and decompoſible by ſtrong heat. I muſt here add that moſt of the metallic phoſphorets are decompoſable by heat.

89. The metallic ſulphurets preſented by nature in ſuch abundance, and under ſuch multiplied forms conſtituting the moſt common ores, preſent, as their remarkable properties, whether in a natural or artificial ſtate, de-

compoſition by a ſtrong heat; eaſy fuſibility with regard to the fuſible metals, and a difficulty of fuſion with regard to thoſe metals which are more fuſible alone; ſulphatization by the contact of the air; analyſis more or leſs eaſy by acids, which diſſolve the metal, and ſeparate the ſulphur, and ſolubility with the formation of ſulphurated and hydro-ſulphurated oxide by the alkalis. We muſt alſo diſtinguiſh the metals which unite beſt with ſulphur after having been oxided, from thoſe which combine with it without oxidation; their combinations with hidro-ſulphuret, and their different attraction for ſulphur, which permits chemiſts to decompoſe ſome of the metallic ſulphurets by other metals; as for example the ſulphuret of antimony by iron, &c.

90. The metals in general unite very well with each other, though there are ſeveral remarkable exceptions in this reſpect. Theſe combinations are in general denominated alloys. Mercury in forming its alloys ſoftens, and even diſſolves moſt of the metals for which reaſon theſe alloys have received the particular name of amalgams. Five or ſix metals may even be united together, ſo as to form complicated alloys of which the arts in ſome inſtances make a great uſe, and which may be ſeparated and examined by the docimaſtic art. A number of theſe metallic compounds are employed in the common purpoſes of life. When metals are united together by fuſion

they never preſerve the ſame denſity and texture as before, nor the intermediate ſpecific gravity which their proportions would afford by calculation. The alloys are always either more denſe, or more rare than the ſum of their primitive denſity would ſhow. And they all poſſeſs new properties as to their fuſibility, their capacity for caloric, their combuſtibility, &c.

SECTION IX.

Concerning the mutual Action of the Metals, of Water, and of the Oxides.

91. THE diſcovery of the decompoſition of water has not yet been conſidered of as great importance as it really is. It has not been ſo highly eſteemed as it deſerves among the great diſcoverers at the end of the century juſt expired, with regard to the immenſe advantages it has afforded to the theory of the knowledge of nature. The hiſtory of the metals has acquired a multitude of explanations of phenomena which were not before comprehended, and would never have been underſtood, but by means of this important diſcovery, one of the moſt beautiful, and moſt ſurprizing, for which we are indebted to modern chemiſtry.

92. There are nevertheleſs, very few metals which poſſeſs the property of decompoſing water alone, becauſe hidrogen in the ſtate of gas decompoſes moſt of the metallic oxides, ſome without heat, and moſt of them by the aſſiſtance of caloric, which proves that this principle has a ſtronger attraction for oxigen than the metals in general have. To this fact we muſt add, that it decompoſes the oxides of ſuch metals as are even themſelves capable of decompoſing water, when they are in a ſtate of oxidation, more advanced than that ſtate in which oxigen ſeized from its union with hidrogen could carry them.

93. We muſt diſtinguiſh with reſpect to the action of metals on water, four claſſes of theſe bodies. Some decompoſe it without heat, and require no aſſiſtance for this purpoſe; a ſhort time only is neceſſary for this decompoſition. Thus it is, that iron placed in contact with cold water, requires ſeveral days to ſeparate the hidrogen, and abſorb the oxigen as we ſee in the preparation of the black oxide or martial ethiops of Lemery, made according to the firſt proceſs. Zinc alſo belongs to this claſs, as well as mangaueſe.

94. The ſecond claſs includes thoſe metals which not being capable of immediately decompoſing water in the cold, become capable of effecting a change by a ſtrong heat at the temperature of ignition. It is probable, that there are many more metals in this condition than

has been imagined. Antimony and tin, in particular are of this order. We may eaſily imagine, that the metals of the firſt claſs acquire by an elevated temperature, the property of decompoſing water much more ſtrongly and abundantly than they decompoſe it in the cold.

95. To the third claſs, I refer thoſe metals, which being incapable of decompoſing water, either at a common or an elevated temperature, while they act alone upon this oxide of hidrogen, acquire this property by a prediſpoſing action, which the acids, and in ſome inſtances, the alkalis exhibit by their tendency to unite with the metallic oxides. This property is found in copper, lead, biſmuth, &c. The metals of the two former claſſes, when treated like thoſe of this third claſs, act with ſtill more energy in the decompoſition of water.

96. In the fourth claſs, I arrange thoſe metals which have not, either by ſimple attraction or by prediſpoſing attraction, or any union whatever of attractive forces, the property of decompoſing water; and which, conſequently never afford hidrogen gas in any circumſtances whatever of chemical combination. Mercury, ſilver, gold, and platina are the only metals of this claſs, and it is eaſy to obſerve, that this property agrees with the other circumſtances; which are ſlight attraction for oxigen, and the facility with which this principle is ſeparable from them.

97. This action of the metals upon water being once accurately determined, it becomes no longer difficult to account for the phenomena they preſent with the acids,—the ſtrong efferveſcence, and the abundant diſengagement of hidrogen gas which accompanies their ſolutions, the reduction of moſt of their oxides by hidrogen gas; and many other circumſtances which were unintelligible, and incapable of explanation in all the periods of chemiſtry, that preceded the diſcoveries of the nature of water.

98. With regard to the oxides it does not appear, that there are any others of which the action on the metals in general requires to be determined, different from the actions of the metals themſelves, ſince nothing has yet been ſeen or determined relative to the effect of the oxides of azote, of phoſphorus, and of ſulphur upon metallic ſubſtances. There are three general circumſtances to be attended to between the metals and their oxides. The firſt relates to the re-action of theſe bodies on their proper oxides, in certain caſes. Though it has been affirmed, that an oxide never unites with its own proper metal, and this obſervation is in general true, it is very remarkable, that if the metal be heated with its oxide in the utmoſt ſtate of oxidation, it frequently happens, indeed, moſt frequently, that the metal aſſumes from its oxide, that portion of oxigen which adheres the leaſt, or which was laſt added, and by that means partly diſ-oxides it, and forms

with it a kind of equilibrium of oxidation. Thus it is, that the red oxide of iron, heated with filings of the ſame metal, cauſes both the filings and itſelf to paſs to the ſtate of black oxide. The ſecond circumſtance depends upon the ſtronger attraction of the metal for oxigen, than that which the oxide exerts upon the ſame principle. In this caſe, the latter is diſoxided, the metal itſelf becomes oxided, and ſometimes even with flame, or more or leſs of light. Laſtly, in the third circumſtance, the metal added to an oxide, having leſs attraction for oxigen than the oxided metal has no change whatever is found to take place between the two bodies.

SECTION X.

Concerning the General Action of the Acids upon the Metals, and the Metals upon the Acids.

99. SINCE chemiſts have treated of metals more particularly with the acids, becauſe theſe agents have always appeared to them to be moſt capable of producing changes and characteriſtic alterations in them: ſince the combinations, they are capable of forming with theſe bodies, have been the object of numerous reſearches; and this part of metallic chemiſtry is moſt abundant with facts, as will more particularly

appear in the hiſtory of the metals individually taken. On the preſent occaſion, we ſhall ſpeak only of the general ſtate of mutual phenomena exhibited by theſe bodies; and conſequently, we ſhall not here examine this action as far as it reſpects each particular acid.

100. In the firſt place, we muſt in general obſerve, that no union takes place between the metals and the acids, unleſs theſe bodies be more or leſs oxided. Accordingly, the metallic oxides which are ſoluble in acids, diſſolve gently, and without effervefcence; though the metals themſelves are not ſoluble without commotion and effervefcence. This laſt effect ariſes from the attraction of the metals for oxigen, being ſuddenly increaſed by the contact of the acids, and cauſes a diſengagement of ſome other principle which takes the form of gas. This principle is afforded either by the acids themſelves, or by the water. In the firſt caſe it may differ, according to the nature and ſtate of the acid: in the ſecond, it is always hidrogen gas, diſengaged with more or leſs of alteration. Sometimes the two bodies, that is to ſay, the acid and the water, are at the ſame time decompoſed by the metal, and then there is a diſengagement either of two gaſes mixed together, or otherwiſe the two principles of theſe gaſes unite, and afford a new compound.

101. The metallic oxides cannot unite or remain united with the acids, unleſs they ſeverally contain certain determinate quantities of oxi-

gen. Short of thoſe proportions, no union of theſe preparations takes place, and beyond them, they fall down in the form of precipitate. Each oxide, in particular, cannot even remain combined with an acid, excepting under limits of oxidation, which are, frequently, very preciſe. For this reaſon it is, that when metallic ſolutions are expoſed to the air, or placed in contact with bodies capable of affording oxigen, they become turbid and precipitate in proportion as they abſorb a greater quantity of that principle than they contained before. It frequently happens, even alone and in well-cloſed veſſels, that the oxides thus ſuſpended, re-act upon their acids by elevation of temperature, and the ſolution becomes turbid, and is decompoſed by this ſpontaneous ſuper-oxidation.

102. Thoſe metals which have the ſtrongeſt tendency to become oxided by the action of the acids, cannot remain united with them, nor form permanent ſolutions. This phenomenon is particularly obſervable in the acidifiable metals, or in thoſe of which the oxides are capable of uniting with the alkalis, and thoſe metals alſo, which are more oxidable than ſoluble in acids, ſeparate in the form of oxides at the bottom, their pretended ſolutions, and remain in a very ſmall quantity, and for a very ſhort time diſſolved in the acids.

103. Metallic ſalts, cannot, therefore, exiſt but in the caſe where the oxides are capable of remaining united with the acids, and have no

tendency to ſeparate. They are not permanent excepting under thoſe circumſtances, wherein, their attraction for oxigen is not increaſed, or when that principle is not preſented to them. The metallic ſalts have always an exceſs of acid, and are beſides for the moſt part acrid, corroſive, and poiſonous. In order to underſtand their properties, it is neceſſary, that we ſhould examine, *a*. Their form. *b*. Their taſte. *c*. Their alteration by light. *d*. Fuſion, drying, volatilization, or decompoſition by caloric. *e*. Deliqueſcence, effloreſcence, or degree of decompoſition by the air. *f*. Solubility in water, hot or cold, or their alteration which is frequently very notable by this liquid. *g*. Decompoſition by the alkalis and earths, the nature and proportions of the oxides which theſe baſes precipitate, the formation of triple ſalts which ſo frequently takes place in this decompoſition. *h*. The alteration of the ſame oxides at the moment of their precipitation, either by the precipitant itſelf, or by the air or by water. *i*. Alteration by the various acids, their decompoſition, or indecompoſition, the effects of the attraction of the acids for the metallic oxides, and the changes theſe laſt undergo. *k*. Action of the earthy and alkaline ſalts, whether it conſiſt in a ſimple union, in a triple ſalt, or preſent a ſingle, double, neceſſary, or ſuperfluous decompoſition. *l*. Mutual action of the metallic ſalts on each other, which is confined to the union of a ſur-compound, the double changes of the baſes, and of the acids, or the diſplacement of oxigen, which precipitates with the oxides at once. *m.* Laſtly, the alterations which combuſtible bodies, whether with or without heat, frequently produce. *n.* Diſoxidation by heated carbon, thoſe operated by the phoſphorus, and the metals without heat; the precipitations by the ſulphurets and hidroſulphurets. After this examination, the hiſtory of a metallic ſalt is as complete as it can be.

104. The various metallic oxides not only poſſeſs different degrees of attraction for the acids, and conſequently, muſt on that account influence the combinations they are ſuſceptible of forming with thoſe bodies; but the metals themſelves, by the force of their attractions for oxigen, alſo produce very remarkable effects. Accordingly ſeveral metals are capable of depriving others of oxigen when they are plunged in a ſolution of theſe laſt in acids; cauſing them to re-appear under their metallic form, as is the caſe with mercury, which reduces ſilver, copper mercury, and iron copper. Sometimes, the metals deprive the oxides of only a portion of their oxigen, ſo that they are not precipitated in the metallic ſtate, but merely in a ſtate of leſs oxidation; thus it is, that tin precipitates gold in the form of a purple oxide, and not in its brilliant metallic ſtate. This phenomenon is of the greateſt importance in a number of technical operations.

105. After having ſhown the moſt general facts relative to the mutual action of acids and the metals; we muſt now obſerve the manner in which each acid exerts itſelf with regard to theſe combuſtible bodies, by conſidering in this place, the acids under the double relation of their peculiar natures, their compoſition, whether known or unknown, and their energy or general attraction for all the baſes with which they are capable of uniting; that is to ſay, by diſpoſing them in the following order, the acids, ſulphuric, ſulphureous, nitric, nitrous, phoſphoric, phoſphoreous, carbonic, muriatic, oxigenated muriatic, fluoric, and boracic. We do not here ſpeak of the metallic acids, becauſe they are not yet ſufficiently known, and their hiſtory at large will follow ſpeedily after this article.

106. The concentrated ſulphuric acid is not decompoſable by the greater number of metals, unleſs the temperature be elevated. When this is the caſe, ſulphureous acid gas is diſengaged, and oxides or metallic ſulphates are formed according to the reſpective quantities of the acid and metals. If the ſulphuric acid be diluted with water, it favours the decompoſition of this laſt fluid by the metals; hidrogen is abundantly diſengaged; the metals in proportion as they become oxided unite with the acid, and form ſulphates in greater abundance than under the preceding circumſtances. The ſulphureous acid acts in a different manner

ner upon different metals. It diſſolves ſome by producing a decompoſition of water and diſengaging hidrogen gas; frequently it is itſelf decompoſed, yielding its oxigen to the metals, ſuffering its ſulphur to precipitate, which unites to the ſulphites, and cauſes them to paſs to the ſtate of ſulphurated metallic ſulphites. Upon ſome of the metals it has no action. As thoſe metals which it diſſolves by its own decompoſition do not effervesſce during their ſolution, it may be uſed with advantage in the analyſis of alloys, carbonated metals, &c.

107. Concentrated nitric acid is frequently without any action whatever upon the metals becauſe its denſity is too great. When it is diluted with a ſmall quantity of water the action commences; nitrous gas is diſengaged; and ſometimes the decompoſition is ſo ſtrong and active, that azote gas is ſeparated. There are caſes, in which the water being decompoſed at the ſame time on account of the large quantity of oxigen abſorbed by the metal, affords ammonia by the union of its hidrogen with the azote of the acid, which is perceptible to the ſenſes, particularly when lime is added. In this caſe the metal remains at the bottom of the veſſel in the form of oxide. When nitrous gas only is ſlowly diſengaged the oxided metal remains in ſolution, and a metallic nitrate is formed, which cryſtallizes by cooling or by evaporation. Of all the acids, this burns the metals the moſt ſpeedily and completely, ſome-

times even with flame, and in theſe inſtances the nitrates of leaſt permanency are formed. Frequently alſo it acts upon oxides ſlightly oxided, gives them a new portion of oxigen, and cauſes them to paſs to the ſtate of acidity when they are ſuſceptible of it. The nitrous acid does not perceptibly differ from the nitric in its action upon the metals.

108. The phoſphoric and phoſphoreous acids, act but weakly upon the metals on account of the ſtrong adherence of their principles, and their denſity. Nevertheleſs, when they are very ſtrongly heated phoſphorated hidrogen gas is diſengaged towards the end. There are ſome among the moſt oxidable metals upon which the phoſphoric acid acts the moſt effectually, and renders them capable of decompoſing water more ſpeedily than they could have done alone. In both caſes phoſphates are formed, and ſometimes phoſphites, which laſt ſalts are yet very little known. The metallic phoſphates are uſually weighty; ſparingly ſoluble, or ſoluble merely in their proper acid, poſſeſs little or no taſte, and are decompoſable by many acids, as well as by ignited charcoal which changes them into metallic phoſphorets. When the vitreous phoſphoric acid is ſtrongly heated with the metals, theſe ſubſtances by ſeizing a portion of its oxigen, form, at the ſame time, two combinations namely, metallic phoſphates and phoſphorets.

109. Carbonic acid, has a ſtill more feeble action on metallic ſubſtances, than all the foregoing acids. It does not very perceptibly act, but upon zinc and iron, by keeping them diſſolved in water. The water is ſlightly decompoſed, a ſmall quantity of hidrogen gas is formed, more diſtinguiſhable by its ſmell than by its diſengagement, which never proceeds ſo far as to effervesce. The metallic carbonates are ſoluble in an exceſs of carbonic acid, and ſeparate from the water when the acid is diſſipated. Some of theſe are very abundantly found in nature. The carbonic acid, united with the earths, and in the ſtate of carbonate, is ſometimes capable of being decompoſed by the metals, with the aſſiſtance of a red heat. Thus it is, that by heating the carbonate of lime with iron, and in fact, by adding the attraction of ſilex or ſand for the lime, and of oxide of iron, with which this fuſible earth tends to become vitrified, Citizen Clouet obtained ſteel, formed by the union of iron, with the carbon ſeparated from the carbonic acid. A ſimilar effect, will, no doubt, be hereafter obſerved, with regard to ſeveral other metals.

110. The muriatic acid does not diſſolve the metals, unleſs they be capable of decompoſing water, by the aſſiſtance of its diſpoſing attraction; in that caſe, hidrogen gas is diſengaged, and it is obſervable, that the gas is ſingularly and permanently fetid. The metals which never decompoſe water, are not attacked by this

acid; but their oxides eaſily unite with it, particularly, becauſe when too much oxided to diſſolve in the other acids, they, at firſt, yield to this acid, the exceſs of their oxigen. On this account it is, that the muriatic acid diſſolves all the oxides, detaches them from the ſurface of veſſels, and ſo frequently takes them from the other acids, particularly the nitric. The metallic muriates are either fixed or fuſible, or volatile, and acidifiable.

111. Oxigenated muriatic acid oxides the metals, without producing commotion or efferveſcence, becauſe the oxigen here acts only upon the combuſtible bodies. It eaſily acts upon thoſe metals which the ordinary muriatic acid does not alter, particularly gold and platina, and in this manner, it forms ſimple muriates. When it is added to the metallic ſalts, it almoſt conſtantly decompoſes them, and precipitates the oxides ſuper-oxigenated. When itſelf united with the oxides, it forms oxigenated muriates very different from the ſimple muriates, which have yet been little examined, though, we are already acquainted with ſome very remarkable compounds of this nature, as we ſhall obſerve in the following articles.

The oxigenated muriatic acid gas inflames and immediately burns moſt of the brittle metals thrown into it in powder. It acidifies thoſe which are capable of that proceſs.

112. The fluoric acid acts upon the metals nearly in the ſame manner as the muriatic, ex-

cept that it does not take the oxigen from their oxides like the latter.

The acid of borax has very little action upon theſe bodies, and cannot be united with their oxides, except by double attraction, or by decompoſing other metallic ſolutions by ſolutions of the alkaline borates.

SECTION II.

Concerning the Mutual Action of the Metals and the Salifiable Baſes.

113. THERE is no more real union between the earthy or alkaline baſes and the metals, than exiſts on the part of the acids, but theſe bodies exerciſe an action with regard to the metals, which, though not ſo powerful as that of the acids, yet it poſſeſſes a peculiar degree of energy, and is of ſome importance to be conſidered. Thus, metals which are acidifiable, and thoſe of which the oxides tend to combine with the earths and the alkalis, are eaſily and ſpeedily oxided when put into contact with theſe baſes, together with a certain quantity of water. In that caſe, the water yields its oxigen to the metals, burns them, and they unite with the baſes, which, in that caſe, act by diſpoſing attraction.

114. Hence, it ariſes, that hidrogen gas is ſo frequently diſengaged when the metals are

treated with alkaline ſolutions, particularly ammonia. We afterwards, obſerve the metals paſs to the ſtate of oxides, and frequently unite with the alkalis in ſuch a manner as to form ſpecies of ſalts; in which, they perform the part of acids.

115. It is frequently obſerved, that alkaline ſolutions diſſolve the metallic oxides, and form with them compounds more or leſs permanent; ſometimes, theſe alkalis have the property of diſoxiding in part the oxides before diſſolved or united with them. This is the reaſon why, when added to the metallic ſolutions, they change the colour of the precipitates, which, they afterwards re-diſſolve, and may be ſeparated by a new addition of acid.

116. Ammonia has much greater power to decompoſe the oxides, while itſelf is decompoſed; and I have elſewhere obſerved, that this is one of the methods Citizen Berthollet uſed to analyze ammonia, by ſeparating its hidrogen by the oxigen of the oxides, and ſetting its azote at liberty. Sometimes, as I have diſcovered, the great quantity of oxigen contained in certain oxides, and the facility it has of ſeparating and uniting in part with the oxide of ammonia forms nitric acid, while the other portion of oxigen combined with the ammoniacal hidrogen forms water. This very remarkable caſe operated by the moſt decompoſable oxides, is abſolutely the inverſe of that in which a very oxidable metal, by decompoſing at the ſame

time the nitric acid and water, by abſorbing all their oxigen, unites the combuſtible radicals, acid, and hidrogen in ſuch a manner, that the product forms ammonia.

117. This property of reducing the oxides, ſo eminently perceptible in ammonia, and ſenſible alſo in pot-aſh and ſoda, may ſerve hereafter to ſhow the conſtituent principles of fixed alkalis, as it has ſerved to develop thoſe of the volatile alkali. But the experiments which have hitherto been attempted in this reſearch, and the reſults they have afforded, have not yet ſatisfied chemiſts, becauſe they have not been made with the accuracy they deſerve to poſſeſs. Philoſophers have been too ready in drawing inductions concerning the compoſition of the fixed alkalis.

118. The diſoxiding property is found in the very ſapid alkaline earths, barites, ſtrontian, and lime; when theſe earths are uſed to decompoſe the acid metallic ſalts, precipitates of metallic oxide are obtained, and aſſume a colour, which ſhows the commencing diſoxidation and approach towards the metallic ſtate. To this action is owing the preparation of the calcareous oxide of copper, known by the name of verditer, of which we ſhall ſpeak under the article Copper.

119. It is not improbable that it may be owing to a ſimilar action, that an extreme ſolidity, and intimate adherence of particles, takes place in earths which are mixed with cer-

tain metallic oxides in the formation of cements and durable mortars, impenetrable to water; which are obtained in many operations, and of which the theory has not yet employed the attention of chemiſts, though it is ſo highly and immediately of conſequence in a multitude of important arts.

120. Though the facts and obſervations hitherto related, ſhow that the earthy and alkaline baſes have more attraction for the acids than the metallic oxides have, we muſt, nevertheleſs, obſerve in this place, that ſeveral of theſe baſes have the property of uniting at the ſame time to the oxides and the acids without ſeparating them, and form by this union triple ſalts, of which the number is much more conſiderable than has been ſuppoſed, as we ſhall ſee in the hiſtory of the various metals. Ammonia and alumine are of all the acidifiable baſes, thoſe which the moſt readily exhibit theſe ſpecies of ſur-compounds yet little known.

121. Laſtly, the alkaline baſes and alkaline earths may alſo unite with the metallic oxides at the ſame time with the combuſtible bodies, to which they have a conſiderable attraction. In this manner the alkaline and metallic hidroſulphurets are formed, by diſſolving the oxides in alkaline or earthy liquid ſulphurets. We ſhall ſee that this effect is alſo produced by precipitating moſt of the metallic acid ſolutions by alkaline ſulphurets, and that when various metallic ſulphurets are treated by the alkalis,

ſimilar combinations are alſo formed, among which the antimonial ſulphurets hold, as we ſhall hereafter ſhow, the firſt rank.

SECTION XII.

Concerning the Mutual Action of the Metals and the Salts.

122. THE ſalts which were formerly denominated middle, or neutral ſalts, have been, and ſtill are, frequently uſed, as very powerful agents to occaſion changes in the metals; in general their action takes place very weakly and ſlowly in a cold temperature; but heat increaſes this action in various degrees. We may eaſily underſtand, from the tranſpoſition of oxigen among the metals, that this action cannot take place but with ſalts of which the acids are decompoſable, and that their reſult muſt be on the one part the oxidation of the metals, and on the other the union of the metallic oxides with the baſe of the ſalt. By enumerating the ſaline genera I ſhall ſhow in what this action conſiſts, and take notice of the action which the metallic oxides ſometimes exert upon theſe compounds.

123. The ſulphates, ſtrongly heated with various metals, particularly thoſe which decompoſe water, and even the ſulphuric acid alone, by the aſſiſtance of heat, paſs to the ſtate of ſulphurates,

ſulphurets, which unite to the metallic oxides formed by this decompoſition; antimony, zinc, iron, and tin particularly poſſeſs this property. The attraction of their oxides for the alkaline ſulphurets, and the hidro-ſulphuret is very effectual in the cauſe of this phenomenon. The oxides of theſe metals have no action on the ſulphates. The ſulphites act much leſs, though in a ſimilar manner upon the metals.

124. The nitrates projected into ignited veſſels, after firſt mixing them with fine filings of metal, take fire with more or leſs brilliancy with moſt of the metals, frequently with a ſmall ſcintillation; but ſometimes with a brilliant flame on account of the fixation of oxigen, which becomes more denſe. In this manner, metallic oxides, at the maximum of oxidation are formed, which often unite with the baſes of the nitrates. Thoſe of the metals which are acidifiable, paſs by this treatment to the ſtate of acids, and combine into ſalts with the ſalifiable baſes of the nitrates. Silver and gold alone reſiſt this violent action of nitre, which is frequently uſed to prepare very perfect oxides with great ſpeed. It may eaſily be conceived, that the metallic oxides undergo no change on the part of the nitrates when they are ſaturated with oxigen, the nitrites are nearly without energy on the metals, in compariſon with the nitrates.

125. The muriates act but very weakly on the metals, and are themſelves but ſlightly altered, nevertheleſs, the muriate of ammonia is eaſily

decompoſed by all the metals, which are very ſoluble in the muriatic acid, as well as by the metallic oxides, which diſengage the ammonia ſtill more rapidly. The alkaline muriates appear alſo to be, at leaſt, in part decompoſable by moſt of theſe oxides; a circumſtance, which may hereafter become of the greateſt importance for the arts, and is already of high value with regard to lead and ſilver, as will be more amply ſhown in the article of theſe metals.

126. The ſuper-oxigenated muriates are the moſt active ſalts with regard to the metals. We have elſewhere obſerved, that they burn with the rapidity and brilliancy of lightning, when ſtruck upon the anvil, after having mixed them with two or three times their weight of ſuper-oxigenated muriate of pot-aſh. A ſimilar mixture being heated, takes fire and detonates with a brilliancy of light and ſpeed much ſuperior to what is ſeen with the nitrates. By this proceſs, very pure oxides are obtained; for the muriate of pot-aſh may be very eaſily and completely ſeparated by waſhing in water.

127. The phoſphates and the phoſphites undergo no alteration on the part of metals at any temperature whatever; and this conſequence is in fact indicated by the common laws of attractions. The ſame obſervation is alſo applicable to the muriates, the borates, and the carbonates. Accordingly, theſe three laſt genera of ſalts can never be uſed to aſcertain the properties of the metals.

128. Though metallic oxides have in general leſs attraction for the acids, than the alkaline and earthy baſes have, we, nevertheleſs, ſometimes obſerve, that theſe oxides when heated with ſaline ſolutions are diſſolved, become coloured, and combine ſo well with the ſalts, that the cryſtals afterwards obtained by evaporation and cooling, are manifeſtly charged with metal. Such, particularly, are the ſolutions of aluminous ſalts which appear to unite very eaſily with the metallic oxides, and afterwards to afford cryſtals, in which true triple ſalts are formed. Theſe caſes are much leſs rare than has hitherto been thought, and they will be more frequently obſerved in proportion as chemical reſearches ſhall be extended with regard to ſaline matters.

ARTICLE II.

Concerning Arſenic and its Acid.

SECTION I.

Concerning Metallic Arſenic.

A. *Hiſtory.*

1. FROM the earlieſt period in which mankind worked the metallic ores, they muſt have aſcertained the volatility, the odour, and the noxious effects of this ſubſtance. Nevertheleſs,

arſenic has remained unknown as a metal, and was not placed among the ſemi-metals or brittle metallic bodies till the expiration of about one-third part of the 18th century: notwithſtanding, Paracelſus had announced, that it might be obtained white in the metallic form. Schroder, in 1649, mentioned a metal extracted from orpiment and arſenic; for we muſt here take notice, that the denomination of arſenic was long given to the oxide of arſenic. Lemery in 1675 alſo deſcribed a proceſs, which is at preſent uſed with ſucceſs in the mixture of fixed alkali and ſoap with this oxide, to obtain what is called the regulus. The ancients were acquainted with its oxide, its yellow and red ſulphuret under the name of arſenic; Sandarach and Orpiment. Theophraſtus placed them among the metallic ſtones. Mineralogiſts were, for a long time, content to range it among ſulphureous matters, and conſider it as a mineralizer of the metals. Brandt in 1733, and Macquer in 1746, ſhowed that is a true metal poſſeſſing properties highly characteriſtic, and different from thoſe of every other metal. Monnet confirmed theſe obſervations by a number of facts in his diſſertation, which obtained the prize of the academy of Berlin in 1773. Macquer made a capital diſcovery in 1748, by carefully examining the reſidue of the decompoſition of nitre by white arſenic, or the oxide of arſenic, which afforded him his neutral arſenical ſalt: but Scheele extended this diſcovery very much in 1775, by ſhowing that this oxide is changed into a powerful acid by the action of the nitric acid ; and by this proceſs, confirmed the ideas of Becher and Kunckel, who conſidered this oxide as a coagulated aqua-fortis. In the year 1777, Bergmann united in one diſſertation, a great part of the properties of this metal in the metallic ſtate, in the ſtate of oxide, and in that of ore: The French or Pneumatic doctrine has claſſed and ſingularly enlightened all the facts relative to the properties of this metal.

B. *Phyſical Properties.*

2. ARSENIC has the form of ſmall plates of a blackiſh grey, brilliant and metallic, whitiſh, and of a lively bright poliſh in its recent fractures, poſſeſſing the ſpecific gravity as ſtated by Bergmann, of 8,310, and by Guyton 5,763. It is extremely brittle, the ſmalleſt effort breaks it into minute fragments; it may be eaſily pulverized by percuſſion, and reduced into a ſubtle powder capable of paſſing through the fineſt ſilken ſieves. It poſſeſſes the laſt rank in the order of hardneſs according to Citizen Guyton. Bergmann, however, affirms that it is harder than copper; it is frequently marked with rainbow colours at its ſurface; its fuſibility is not known, becauſe it ſublimes before it melts; it is the moſt volatile of all the metals; it

cryſtallizes when ſlowly ſublimed in a regular tetrahedron, and ſometimes in the form of an octahedron. The firſt form is that of its integrant particles. Neither its taſte nor ſmell are very perceptible when cold: nevertheleſs, it leaves on the fingers a ſlight metallic taſte, and in the mouth, a ſharp peculiar taſte, which is very diſagreeable. When it is heated, it poſſeſſes the form of vapour, and exhibits a very ſtrong fetid ſmell of garlic, which may be conſidered as the characteriſtic token of its preſence. Neither its dilatability by caloric, nor its conducting power of that ſubſtance, or of electricity, have been eſtimated.

C. *Natural Hiſtory.*

3. Arsenic frequently exiſts native in ores; it has, almoſt always the form of blackiſh maſſes of little brilliancy, very heavy, exhibiting no metallic ſplendor but in their fracture, which, frequently preſents rainbow colours. Its fracture is almoſt always ſcaly and conchoidal. This metal was long confounded with the ores of cobalt, and denominated teſtaceous cobalt. It varies in its colour from deep grey to black: in its lamellated form, ſcaly, pulverulent; and its ſtate of depoſition of ſtalactites, of incruſtation, of cryſtals; it is often found with the ores of cobalt, of biſmuth, of nickel, of ſilver, in Saxony, Hungary, Bohemia, and at the mines of St.

Mary. It may be unequivocally aſcertained by throwing a few ſmall fragments upon ignited coal; a white fume inſtantly riſes with the ſmell of garlic.

4. Nature frequently preſents arſenic combined with other metals. We are not yet well acquainted with ores of this kind, except the miſpickel, or arſenical pyrites, which is a true alloy of iron and arſenic with ſulphur. Iron compoſes from one-half to two-thirds of its maſs according to Bergmann, though it is not attracted by the magnet. When this native alloy is heated, the arſenic ſublimes, and the iron remains partly reduced and attractable by the magnet. This alloy cryſtallizes in cubes, of which the angles are often truncated.

5. A third, very frequent ſtate of arſenic in nature, is that of its combination with ſulphur. It preſents two principal varieties, the one yellow, known under the name of orpiment, the other red, named Realgar, which are ſometimes tranſparent, and often opaque. The yellow affects the lamellated form, and the red the priſmatic. We are not yet well acquainted with the difference of theſe two compounds in which the arſenic appears to be but little oxided. They frequently aſſume a pyramidal or tetrahedral form conſiderably perfect; ſometimes in the maſs of calcined ore of arſenic we obſerve only pyramids of ſulphuret of arſenic, compoſed of filaments parallel to the ſides; ſo that one of the hollow triangular pyramids being frequently filled with ſmall

pyramids, produces a tetrahedron with the other pyramids progreſſively decreaſing, and the eight tetrahedrons ſuitably diſpoſed produce the octahedron. Here, as Bergmann obſerves, from whom this deſcription is taken, we ſee a cryſtallization in the dry way abſolutely ſimilar to that which is afforded in the humid way by muriate of ſoda, the muriate of pot-aſh, and perhaps, all the other ſalts. We ſee, that this ſkilful chemiſt noticed the laws of diminution to which Citizen Haüy has paid ſuch ſucceſsful attention. The yellow and red ſulphurets of arſenic vary in their form, and the ſhade of their colour. They are found in numerous places in the vicinity of Volcanos; particularly at Veſuvius and Quito. Sometimes, they are alloyed with iron, in which caſe, their colour is pale, and even becomes white. Theſe ſulphurets are totally ſublimable.

6. Arſenic is ſometimes found in the earth in the ſtate of pure white oxide, or arſenious acid, as we ſhall ſee hereafter: but this is ſcarce, and always in ſmall quantity. In the territories already mentioned, it is formed either in powder or in effloreſcence, or in white maſſes depoſited in ſtrata, ſometimes tranſparent, frequently mixed with yellow or red ſulphuret of arſenic. It is diſtinguiſhed by its garlic vapour, when thrown in the fire, as well as by its acrid metallic taſte, and its ſolubility in water.

7. We are, not yet acquainted with the nature of the oxide of arſenic united to acids.

On the contrary, we know that this metal in the ſtate of acid, is frequently itſelf the mineralizer of various other metals.

D. *Docimaſtic and Metallurgic Operations.*

8. Nothing can be more ſimple and eaſy than the aſſay of the ores of this metal, ſince it conſiſts merely in aſcertaining its preſence by the white fume and the odour of garlic which they preſent when thrown on ignited coal. A true aſſay of theſe ores for metallic works is never made.

9. In ſcientific chemiſtry, if it be deſired to aſcertain the quantity of metal contained in a native oxide of arſenic, or which is the ſame thing, to obtain metallic arſenic from its oxide, this ſubſtance is mixed with three times its weight of black flux; the mixture is put into a crucible and covered with another reverſed and luted in ſuch a manner as to prevent the acceſs of air. The lower crucible is heated by degrees to ignition, at the ſame time that the upper is defended from the heat, and the flame by a perforated copper-plate. When the apparatus is cool, the upper crucible is found to contain a cruſt of metallic arſenic, brilliant and cryſtallized, eaſy to be detached, of which the weight may be compared with that of the ore, or rather the oxide employed.

Bergmann, in his Diſſertation on the Humid Analyſis, directs us to aſſay native arſenic by diſſolving it in four parts of nitro-muriatic acid, concentrating the ſolution by evaporation, and precipitating by water the muriate of arſenic. The filtered liquor contains the other metals which may exiſt in the ore. If it contain ſilver, this may be thrown down in the form of inſoluble muriate. Iron is frequently found in the ſolution precipitated by water.

11. The ſulphuret of arſenic muſt be treated with the muriatic acid, by adding a ſmall quantity of nitric acid to ſeparate the ſulphur; this laſt is collected, waſhed, and weighed; the oxide of arſenic is alſo capable of being precipitated by water; arſenic may alſo be obtained in the metallic ſtate by immerſing zinc in the muriatic ſolution, after having added alcohol. If it contain iron it remains ſuſpended. By this aſſay it is determined that the different proportions of ſulphur occaſion the variations of colour in the ſulphurets of arſenic.

12. With regard to the native oxide of this metal, its aſſay muſt alſo be made by the muriatic acid, which diſſolves it. Bergmann very properly recommends that the nitric acid ſhould be uſed with great caution in theſe aſſays, becauſe it eaſily converts the arſenic into the acid ſtate, which is no longer precipitable by water; he even remarks, that a ſmall portion is conſtantly formed, which unites with the earths and metallic oxides exiſting in the ores of arſenic, and of which it is neceſſary to take account in an accurate docimaſtic analyſis.

13. The ores of arſenic are not treated in the large way for the purpoſe of obtaining the metal; its two products are obtained in the treatment of ſeveral other ores, particularly thoſe of cobalt; and both are extremely dangerous in their uſes. In Saxony and Bohemia the oxide of arſenic, or a true arſenious acid is obtained during the roaſting of the ore of cobalt. Theſe products ſublime and fix themſelves in long horizontal chimnies proceeding from the furnaces. This article is ſold under the name of white arſenic.

14. Loaves, or maſſes of metallic arſenic, of a blackiſh-grey colour, are alſo prepared in the large way, conſiſting of plates irregularly arranged, ſo as to leave a great number of pores and cavities. Theſe, probably, are obtained in the large way by treating other arſenical ores; and they are ſold under the dangerous and deceitful name of teſtaceous cobalt, or powder for killing flies. Bergmann, who alſo rejects this erroneous expreſſion, is deceived when he affirms that this ſubſtance does not kill flies unleſs it be in the ſtate of oxide. The experiments of our peaſants, who ſtrew this powder in plates containing water, which are placed even on dining tables, and ſoon become filled with dead flies, proves that the metal itſelf, though inſoluble, is extremely poiſonous.

E. *Concerning the Oxidability of Arſenic by the Air.*

15. Arsenic, in the brilliant metallic ſtate, and recently prepared, ſoon changes, even in the cold, by the contact of the air. Its ſurface is oxided at firſt of a dull colour, and at laſt becomes black, at the ſame time that it loſes its hardneſs, and becomes extremely friable, and even pulverulent.

16. When it is heated with the contact of air, and particularly when its powder is thrown on red-hot coals, it burns with a very perceptible blue flame; it emits fumes having a ſtrong ſmell of rotten garlic, and it ſublimes in a white, acrid, ſoluble maſs, which has been denominated oxide of arſenic, but which I ſhall deſcribe under the name of the arſenious acid. Citizen Guyton places it in the ſeventh rank of oxidability after antimony. I conſider it as one of the moſt combuſtible among metallic ſubſtances.

F. *Union with Combustible Matters.*

17. No union is known to ſubſiſt between arſenic, azote, carbon, and the diamond; it is known to be ſoluble in hidrogen gas, to which it gives a fetid ſmell, and poiſonous property. Its combinations with phoſphorus, ſulphur, and the metals have been determined.

18. When equal parts of phoſphorus and arſenic are diſtilled with careful management of the fire, a brilliant blackiſh ſublimate is obtained which burns on ignited coals with a mixed odour of theſe two combuſtible bodies. A black reſidue is left abounding with phoſphorus, which muſt be kept under water, and is the phoſphoret of arſenic. This combination may alſo be made under water at a boiling heat in a glaſs veſſel; the phoſphorus unites with the arſenic by fuſion. The characters of this phoſphoret of arſenic are not yet known.

19. Arſenic is eaſily combined with ſulphur by fuſion and by ſublimation. It then forms a yellow or red compound. This laſt colour ſhows that the metal preſerves its metallic nature. For when this compound is oxided by the action of acids it paſſes to yellow. It is a perfect imitation of the native red ſulphuret of arſenic, or realgar, which has ſometimes been named on account of its colour, the ruby of arſenic. The alkaline ſulphurets alſo diſſolve, arſenic with facility, which adheres to them but weakly, and is eaſily ſeparated by all the other metals. The hidro-ſulphuret of arſenic is not yet known.

20. Arſenic unites very eaſily with moſt of the metals. As it is the firſt metal which is examined individually in this work we cannot treat of its alloys, but in a general manner; becauſe we ſhall return to them under each of the twenty following metals. By uniting with

the ductile metals, arſenic renders them brittle; thoſe which are difficult to fuſe, become much more fuſible by this treatment, and thoſe which melt eaſily become refractory. It whitens the yellow and red metals; it renders the white metals grey: in general it communicates brilliancy and hardneſs, and conſequently a more conſiderable ſpecific gravity, with the property of obtaining a higher poliſh than before. Nature frequently preſents it alloyed with the metals, and it is conſidered in mineralogy as one of the moſt frequent mineralizers. The arſenicated metals loſe their arſenic by the action of fire; but this volatile metal carries a portion of the others with it; and theſe alſo frequently retain a portion of the arſenic ſo ſtrongly as not to be ſeparated but with much difficulty.

G. *Action upon Water and the Oxides*

21. ARSENIC does not decompoſe water, notwithſtanding its tendency for oxigen; on the contrary we ſee its oxide decompoſed by heat, with hidrogen and hidrogenated bodies. Caloric does not favour the decompoſition of water by this metal.

22. It ſeizes the oxigen from the oxide of azote, and becomes converted either into arſenious acid, or arſenic acid, by the action of nitrous gas long continued. We muſt here recollect that the oxide of azote during its for-

mation abſorbs a portion of caloric which renders the union between the acid and oxigen leſs powerful, and that upon this account nitrous gas is more decompoſable than the nitric acid, and is the firſt decompoſed by combuſtible bodies in the nitrous acid, of which it forms a conſtituent part, as has been obſerved in the hiſtory of the acids of nitre.

23. The action of arſenic on the oxides of phoſphorus and ſulphur, has not been appreciated; it appears nevertheleſs, that it is inſignificant, ſince phoſphorus and ſulphur always tend to diſoxigenate the oxides and acids of arſenic, as we ſhall ſee.

24. Arſenic decompoſes ſeveral metallic oxides either in the dry or the humid way. In general thoſe metals which have little attraction for oxigen, and particularly thoſe which have not abſorbed it in the ſolid ſtate are capable of burning arſenic with activity, and even with flame when heated with theſe oxides. We ſhall return to this phenomenon, in the hiſtory of ſeveral of the following metals. This effect is not produced on manganeſe, zinc, tin, and iron, becauſe theſe metals decompoſe its proper acidified oxides as we ſhall ſpeedily remark.

H. *Action of Arſenic upon the Acids, and of the Acids upon Arſenic.*

25. In general, thoſe acids only which are eaſily decompoſed, appear capable of acting upon arſenic and ſupplying it with oxigen. Few of them can hold it in ſolution, on account of the acid nature which it aſſumes by its oxidation; it therefore, always falls down in the form of a white powder from its ſolutions. Moſt of the acids, by a conſiderable action upon arſenic, convert it into arſenic acid, or at leaſt into arſenious acid; and it has then much more tendency to unite with the alkalis, than to combine with the acids; accordingly, it ſeparates from the latter, or at leaſt it does not unite with them; when, therefore, we obtain ſolutions of arſenic, they are always made with exceſs of acid, little charged with oxide; they have little permanency, they become turbid by evaporation, or by the ſimple addition of water.

26. The concentrated ſulphuric acid does not attack arſenic in the cold; when it is boiled upon this metal in powder or in ſmall fragments, it produces an effervefcence; ſulphureous acid gas is diſengaged: the arſenic becomes oxided and remains at the bottom of the veſſel in a white powder, which retains but little ſulphuric acid; waſhing with water carries off moſt of this laſt, and leaves the arſenic with little diminution. There is not, truly, a ſul-

phate of arſenic. No cryſtals are obtained from this ſolution; by evaporation, the arſenious acids falls down, and the ſulphuric acid remains ſuſpended. No action takes place between the ſulphureous acid, and the arſenic acid.

27. Concentrated nitric acid attacks arſenic in powder with much vivacity, or rather this metal rapidly decompoſes the nitric acid; nitrous gas is diſengaged, and towards the end azote. The arſenic is changed into a white powder much heavier than the metal was before. It is firſt the arſenious acid which may paſs to the ſtate of arſenic acid, if a new quantity of nitric acid be made to act upon it; ſometimes, even when a large quantity of this acid has been taken, and its action is aſſiſted by heat, the metal ſpeedily becomes arſenic acid, and no oxide remains in the ſupernatant acid, ſo that there is no nitrate of arſenic afforded. Chemiſts who have ſpoken of ſuch a nitrate, obtained a ſolution of arſenic acid, and conſequently were induced to aſſert, that the alkalis do not precipitate this metal. The nitrous acid produces this effect of acidification upon arſenic ſtill more ſpeedily.

28. There is no perceptible action between the phoſphoreous and phoſphoric acids and arſenic; by means of an elevated temperature continued for ſome time, a ſmall quantity of arſenic is oxided, but weakly and almoſt in an inſenſible manner: the ſame obſervation applies to the carbonic acid.

29. The muriatic acid has no action in the cold upon arſenic; when it is made to boil, it perceptibly diſſolves it, and gives out a fetid gas, which appears to be arſeniated hidrogen. The muriatic acid, therefore, renders water decompoſable by arſenic. Bergmann has remarked, that this acid is the beſt ſolvent of the metal here ſpoken of, and accordingly, he has recommended it for the aſſays of its ores. A ſmall quantity of nitric acid being added, renders the ſolution more ſpeedy. This ſolution heated and concentrated in cloſed veſſels, ſublimes totally in the form of a thick fluid, which was denominated butter of arſenic. It is decompoſed by water alone, which ſeparates the arſenious acid. It is, therefore, only a tranſient muriate of arſenic, which cannot be compared to a true metallic ſalt.

30. The oxigenated muriatic acid acts upon arſenic with much greater force and rapidity. This metal, when thrown in the ſtate of powder into oxigenated muriatic acid gas, becomes inſtantaneouſly inflamed, and burns with a white and very bright flame; it afterwards exiſts in the ſtate of arſenious acid. If we add to it liquid oxigenated muriatic acid, it ſpeedily paſſes into the ſtate of arſenical acid, whilſt the former is reſtored to the ſtate of ordinary muriatic acid. The ſame acidification is effected by pouring oxigenated muriatic acid into the ſolution of arſenic by the ordinary muriatic acid.

31. The fluoric and the boracic acids exert no action at all upon arſenic. We ſhall ſee hereafter what are its habitudes with reſpect to the metallic acids, and even with reſpect to its own or the arſenic acid.

I. *Action of the Baſes and Salts upon Arſenic.*

32. No earthy or alkaline baſe exerts any real action upon arſenic, nor effects any oxigenation of it by water, at leaſt unleſs we boil this metal for a long time, in the ſtate of fine powder, in a large quantity of alkaline ſolution. Ammonia is equally inert with reſpect to this metal.

33. The ſulphates are not decompoſed by arſenic; the heat which it would be neceſſary to employ in order to favour this decompoſition, is ſuperior to that which volatilizes this metal; ſtill leſs can it ſuffer any alteration by the action of the ſulphites.

34. The nitrates burn arſenic and detonate with it. They convert it into arſenical acid by the great quantity of oxigen which they impart to it; and this acid, combining with the baſes of the nitrates, forms arſeniates which remain at the bottom of the veſſels in which this operation is carried on.

35. No action, no combination, no decompoſition is known between arſenic and the muriates. The ſuper-oxigenated muriates, on the contrary, exert a conſiderable action upon this

metal. When three parts of ſuper-oxigenated muriate of pot-aſh have been mixed with one part of arſenic in fine powder, (a mixture which muſt be made with great caution, and without applying much friction or compreſſion to the ſubſtances, leſt ſpontaneous inflammation and detonation ſhould take place), if we ſtrike ſmall portions, placed upon an anvil or folded in paper, with a hammer, a conſiderable fulmination attended with flame is produced. If we approach a body in the ſtate of combuſtion to the ſame mixture, it kindles and burns with exceſſive rapidity. Poured upon concentrated ſulphuric acid, it emits a flame, at the inſtant of contact, which raiſes itſelf in the air, flaſhes like lightning, and is ſo brilliant that it dazzles the eyes.

36. No action is known to be exerted upon arſenic by the phoſphates, which themſelves undergo no alteration. The phoſphites when heated with this metal, yield a ſmall quantity of phoſphuret of arſenic.

37. The fluates, borates, and carbonates exert no action at all upon it; when we heat it with borax by means of the blow-pipe, it becomes volatile, burns, and does not remain fixed in the vitreous globule formed by this ſalt.

K. *Uſes of Arſenic.*

38. ARSENIC, in the metallic form, and ſuch as it has been deſcribed in this paragraph, is

but little employed, except in chemical laboratories, where various experiments, reſearches, and demonſtrations are carried on.

39. As it is ſometimes employed for killing flies, great caution ſhould be uſed in applying it to this purpoſe; for this ſubſtance, which is ſold under the name of teſtaceous cobalt, or fly-powder, is very dangerous to all animals, though ſome chemiſts are of the contrary opinion. The antidotes againſt its poiſon ſhall be enumerated hereafter.

40. In ſome manufactories it is alloyed with various metals, in order to whiten and harden them; the white copper is frequently an alloy of this kind. We ſhall ſpeak of this ſubject in the hiſtory of the other metallic ſubſtances; it is only of importance to obſerve in this place, that, though ſuch alloys may be of utility in ſome caſes, they ought never to be employed in utenſils for the preparation of aliment, drinks, or medicines.

SECTION II.

Of the Arſenious and Arſenical Acids.

SPECIES I.

The Arſenious Acid.

1. I WAS the firſt who applied, ſome years ago, the name of arſenious acid *(acide arſenieux)* to the ſubſtance which is known in commerce by the name of *white arſenic*, *(arſenic blanc)*, and which has been termed oxide of arſenic in the Methodical Chemical Nomenclature. The manifeſtly, though ſlightly, acid properties of this pretended oxide, which had already been ranked amongſt the acidified ſubſtances by ſome of the ancient chemiſts, induced me to do ſo, as well as the advantage of comparing its properties in the hiſtory of arſenic and the arſenical acid, with thoſeof the phoſphoreous and ſulphureous acids, in the hiſtory of phoſphorus, ſulphur, and the phoſphoric and ſulphuric acids.

2. This acid is found frequently, if not abundantly, in nature; it is known, and I have myſelf indicated it amongſt the arſenical ores, by the name of *native oxide of arſenic*: it is obtained in the large way, and ſublimed in working various ores, eſpecially thoſe of cobalt. It is prepared by heating and burning arſenic in ſubliming apparatuſes, to which the air has ac-

ceſs; it is alſo this ſubſtance which is formed when the arſenic is ſuppoſed to be ſimply oxided by the ſulphuric, nitric, muriatic, and oxigenated muriatic acids; finally, it is this weak acid which reſults from all the circumſtances in which arſenic is oxided to whiteneſs; ſo that there is no real oxide of this metal except that which is black.

3. The acid characteriſtics of this burned ſubſtance are the acrid taſte, its cauſtic and *poiſonous* property, that of changing feeble blue colours into red, of precipitating the alkaline and earthy ſulphurets, of diſſolving in water, of uniting with the alkalis and earths; and, as a weak *poiſonous* acid, it is volatile, leſs ſoluble than the arſenical acid; its ſalts are much more decompoſable than thoſe of the latter: but its differences and variations will be better underſtood by ſtudying its real properties.

4. The arſenious acid is very volatile: when we heat it ſlowly in cloſe veſſels, it ſublimes in regular tetrahedral cryſtals, which are tranſparent like glaſs. Frequently the tetrahedrons have their angles truncated. It forms denſe, ſemi-tranſparent layers in the chimnies where the ores of cobalt are worked, appearing in the form of a powder or of ſmall needles: this was formerly termed *flowers of arſenic.* This acid is ſo extremely acrid and cauſtic, that it corrodes the organs of animals; it is the moſt deleterious of all known poiſons. Its ſpecific weight is leſs than that of arſenic; it weighs between 4,000

and 5,000: the oxigen with which it is combined keeps therefore the molecules of the arſenic more ſeparate from each other than in their metallic ſtate; it reddens the moſt ſenſible and alterable blue vegetable colours, though it turns the ſyrup of violets green; when expoſed to the air, it becomes opaque and covered with a ſlight efflореſcence.

5. The arſenious acid is very eaſily alterable by hidrogen, carbon, phoſphorus, and ſulphur; the two firſt deprive it of its oxigen in a red heat, and cauſe it to return to the ſtate of arſenic; the one forming water, and the other carbonic acid. The phoſphorus and ſulphur become in part acid, and in part conſtitute with the arſenic, which they reſtore to the metallic ſtate, arſenical phoſphoret or ſulphuret. It is on this account that Margraff and Pelletier, who have particularly occupied themſelves with the metallic phoſphorets, have ſaid that we might form them with white arſenic, or the arſenious acid.

6. Water diſſolves the arſenious acid pretty eaſily; it requires no more than twenty-four parts at ten degrees to diſſolve one part of the acid; hot water diſſolves more of it than cold, for fifteen parts of boiling water are ſufficient to diſſolve one part of this acid; the ſolution alſo depoſits cryſtals.

By refrigeration, but much better by evaporation, regular tetrahedrons are obtained from it. This ſolution is very acrid, reddens the blue colours, unites with the earthy baſes, decompoſes the alkaline ſulphurets, and yields with them a yellow precipitate, in which the arſenic approaches the metallic ſtate. There are even ſome metals which act upon this ſolution, and which tend to decompoſe the acid, ſo as to form a blackiſh precipitate, which approximates to the ſtate of arſenic.

7. Between this and the other acids no action takes place, except one of a very differentnature from that which they exert upon the metals; boiling ſulphuric acid diſſolves a ſmall quantity of arſenious acid, which is precipitated by refrigeration; nitric acid, without diſſolving it, becomes decompoſed with the aid of heat, and converts the arſenious into arſenical acid. The phoſphoric and carbonic acids do not act upon the arſenious acid; nevertheleſs, this acid enters into a vitreous combination with the phoſphoric and boracic acids. Muriatic acid diſſolves it with the aid of heat, and forms a volatile combination which water precipitates; the oxigenated muriatic acid converts it into arſenical acid.

8. The arſenious acid combines with the earthy and alkaline baſes; the firſt form with it arſeniates that have little ſolubility; hence its ſolution is precipitated by thoſe of barites, ſtrontian, and lime. The fixed alkalis form denſe arſeniates, which do not cryſtallize, which are decompoſable by fire, of which caloric volatilizes the arſenious acid, and from which all

the acids precipitate it in a pulverulent form. Theſe ſaline combinations were formerly termed *livers of arſenic*, as they were compared with the compounds of ſulphur and the alkalis. The earthy and alkaline arſenites have as yet been but little examined. What is known of them is barely ſufficient to diſtinguiſh them from the arſeniates, or the compounds reſulting from the combination of the arſenical acid with the ſame baſes.

9. There exiſts ſtill another ſpecies of combination between the arſenious acid and the earths; namely, thoſe which are formed in employing it for the purpoſe of vitrification. Though a portion of this volatile acid is ſublimed previous to the fuſion of the glaſs, another part remains fixed in the vitrified ſubſtance, which gives it tranſparency, an homogeneous denſity, and a conſiderable weight: it even appears that there exiſts in the arſenicated glaſſes a kind of triple ſalt; for the alkalis and the ſand enter into intimate combination at the moment of fuſion, and remain intimately united.

10. If we except the nitrates and oxigenated muriates, the other ſalts have but little action upon the arſenious acid; it exerts none upon the ſulphates, the muriates, and the fluates; it is only with the aſſiſtance of heat that it decompoſes the carbonates, from which it expels the acid with effervefcence, in order to unite with their baſes; it is not without difficulty that it

expels and precipitates the acid of the borates. It is, however, to be remarked, that on heating the muriate of ſoda with the arſenious acid, a portion of its muriatic acid is diſengaged.

11. But the nitrates and the ſuper-oxigenated muriate of pot-aſh act in a very remarkable manner upon the arſenious acid; it decompoſes the firſt in ſuch a manner as to diſengage from them the nitrous acid, or nitrous vapour, which it is very difficult to coerce, as Kunckel had long ago obſerved; it abſorbs a part of its oxigen; it paſſes into the ſtate of arſenical acid, and it leaves arſeniates in the diſtilling veſſels. The ſame phenomenon takes place when we detonate the arſenious acid with the nitrates; for it is ſtill ſufficiently combuſtible to effect a detonation, without ſparks indeed, but with commotion and efferveſcence; and real arſeniates remain at the bottom of the crucibles. It was in this manner that chemiſts formerly prepared *fixed arſenic*, which is the acidulous arſeniate of pot-aſh, concerning which we ſhall treat hereafter. The ſuper-oxigenated muriate of pot-aſh alſo, by completely burning the arſenious acid, effects its converſion into arſenical acid, which is able, with the aid of fire, to decompoſe the remaining muriate of pot-aſh.

12. The arſenious acid is applied, under the name of arſenic, or white arſenic, to a variety of uſes in the arts; it is employed in a great number of caſes, in which it is reduced and acts

as a metal, as ſhall be ſhown hereafter. Some phyſicians have ventured to employ this terrible acid as a medicine, and aſſure us that they have found it very efficacious; but it is always much more to be dreaded as a poiſon, than eſteemed as a remedy. Waters charged with ſulphurated hidrogen gas are amongſt the beſt counter-poiſons that can be adminiſtered againſt the effects of this dangerous ſubſtance. The alkaline ſulphurets diſſolved in water, prove very ſuccefsful, immediately after a perſon has been poiſoned with arſenic; bland inſipid liquids, milk, fat, oils, are ſometimes rather dangerous than ſalutary, as they envelop, and in ſome meaſure, fix the arſenious acid upon the ſtomach.

SPECIES II.

The Arſenical Acid.

1. THOUGH Macquer firſt aſcertained the difference between the combinations of this acid and thoſe of the preceding, it was not till the year 1775 that Scheele diſcovered the artificial formation of the arſenical acid, by diſtilling nitric acid upon a muriatic ſolution of arſenious acid, which he believed to exiſt in the oxide of arſenic. This able Swede was the firſt who deſcribed the remarkable properties of this acid. He alſo prepared it by treating the ar-

ſenious acid with the oxigenated muriatic acid: Bergmann added ſeveral uſeful facts to this diſcovery. The pneumatic theory proved to the French chemiſts, that, during this converſion into a more powerful acid, the arſenious acid abſtracted oxigen from the nitre or the nitric acid, and from the oxigenated muriatic acid. Pelletier, on examining various properties of this acid, found that by decompoſing the nitrate of ammonia by means of the arſenious acid, and afterwards applying heat till the ammonia was diſengaged, the arſenical acid was left alone and pure at the bottom of the diſtilling veſſel.

2. The arſenical acid is prepared, either by diſtilling ſix parts of concentrated nitric acid from the arſenious acid, or by heating concentrrted nitric acid upon twice its weight of a muriatic ſolution of arſenious acid, or by diſſolving the latter in liquid oxigenated muriatic acid, or by receiving this, in the form of gas, into a ſolution of arſenious acid. In all theſe proceſſes we obtain an acid which does not cryſtallize, which has a dreadfully acrid and cauſtic metallic taſte, which is fixed in the fire, and can ſooner be fuſed into glaſs than volatilized; which reddens even the ſyrups of violets, and which has much ſtronger attractions than the arſenious acid. Its ſpecific weight is 3, 391.

3. When we heat this acid in a retort or a crucible, it melts quietly; it attacks the glaſs of the retort or the earth of the crucible; it remains tranſparent and pure at a very high temperature;

perature; it yields a ſmall quantity of oxigen gas, and returns in part to the ſtate of arſenious acid: bright light alſo favours this diſacidification, which particularly takes place when we ſtrongly heat this powerful and cauſtic acid in a tranſparent veſſel. When the arſenical acid contains a ſmall quantity of arſenious acid, we ſeparate the latter from it by the action of fire, as is done with the ſulphureous and nitrous acids, when united with the ſulphuric and nitric acids.

4. Expoſed to the air, it quickly attracts humidity; it is entirely and completely deliqueſcent; it abſorbs alſo two thirds of its weight of atmoſpherical water, a quantity ſufficient to hold it in ſolution.

5. When the arſenical acid is heated with combuſtible ſubſtances, of whatever kind they may be, they decompoſe it, abſtract from it its oxigen, cauſe it to return into the ſtate of arſenious acid, and from thence into that of arſenic. Alſo hidrogen gas, received into a ſolution of this acid, poſſeſſes this property in a ſufficient degree to precipitate its ſolution; ſtill more decidedly muſt this effect be produced by ſulphurated hidrogen gas, by water charged with it, and by the alkaline ſulphurets. Carbone, phoſphorus, ſulphur and moſt of the metals produce the ſame effect, either by the aid of caloric, or even by ſimple contact, as is obſerved with ſeveral of the laſt mentioned ſubſtances: heated with carbon in a retort, the arſenical acid inflames the carbon, and paſſes

into the metallic ſtate. Sulphur heated with the arſenical acid, puffs up, is converted partly into ſulphureous acid gas, and partly ſublimes into red ſulphuret of arſenic; heated with phoſphorus, it converts a portion of it into phoſphoric acid; and having become arſenic, it unites with another portion of the phoſphorus, with which it forms phoſphoret of arſenic, which ſublimes. Arſenic, or the metal itſelf, heated with arſenical acid, deprives it of a portion of its oxigen; and the two ſubſtances, united reciprocally in an equilibrium of oxidation, paſs together into the common and uniform ſtate of arſenious acid.

6. The arſenical acid is much more ſoluble in water than the arſenious acid; it requires not more than three or four parts water, in order to become well diſſolved and fluid; it cannot by any means be cryſtallized, and when evaporated, it aſſumes a thick conſiſtence like that of honey. It does not act in the cold upon the oxides, which diſcompoſe it at a high temperature; it combines with various metallic oxides, as ſhall be ſhown more at length under the ſubſequent articles.

7. None of the acids exert any action upon the arſenical acid: though ſome of them diſſolve it by means of their water and their liquid ſtate, they do not induce any alteration in it. The boracic and phoſphoric acids, with the aid of fire, enter with it into the ſtate of vitrification, but without mutually changing the nature of each other. The phoſphoreous acid,

when heated for ſome time upon arſenical acid, ſaturates itſelf with oxigen, and becomes phoſphoric acid.

8. The arſenical aeid combines with all the earthy and alkaline baſes, forming ſalts very different from thoſe afforded by the arſenious acid. All the earthy and alkaline arſeniates are decompoſable by carbon, which, with the aid of heat, ſeparates arſenic from them. The arſeniate of barites is inſoluble, uncryſtallizable, ſoluble in an exceſs of its acid, decompoſable by ſulphuric acid, which precipitates ſulphate of barites from it. The arſeniate of ſtrontian is not known, but it is certainly analagous to that of barites.

9. Poured into lime-water, the arſenious acid forms in it a precipitate of lime ſoluble in an exceſs of its baſe, or an exceſs of its acid, though it be inſoluble alone. The acidulous arſeniate of lime yields, by evaporation, ſmall cryſtals that are decompoſable by the ſulphuric acid. The ſame ſalt is formed with the carbonate of lime, introduced into the ſolution of arſenical acid. This acid does not decompoſe the nitrate and muriate of lime, but the ſaturated alkaline arſeniates decompoſe them by a double attraction, and precipitate from them inſoluble calcareous arſeniate.

10. When we ſaturate the arſenical acid with magneſia, a thick ſubſtance is formed as it approaches the point of ſaturation. This magneſian arſeniate is ſoluble in an exceſs of acid ;

by evaporation it aſſumes the form of a jelly, without cryſtallizing. The arſenical acid decompoſes neither the ſulphate, nor the nitrate, nor the muriate of magneſia; this decompoſition is effected only by the ſaturated alkaline arſeniates.

11. The arſenical acid ſaturated with potaſh, does not cryſtallize; evaporated to dryneſs, the arſeniate of pot-aſh attracts the humidity of the atmoſphere; it turns the ſyrup of violets green, but does not alter the tincture of turnſole. This ſalt melts into a white glaſs; the contact of the ſilex and alumine of the crucible over a ſtrong fire, cauſes it to paſs into the acidulous ſtate, of which I ſhall ſpeak immediately. It puffs up violently and yields well-ſublimed arſenic, when heated with carbon to redneſs in cloſe veſſels; it is decompoſed by the ſulphuric acid, which diſengages the arſenical acid from it: this decompoſition is not perceptible by the humid way, becauſe the arſenical acid is not ſeparated in the ſolid form, but remains in ſolution; but we find ſulphate of pot-aſh and the laſt-mentioned acid in the mother water, on evaporating the liquid. The arſeniate of pot-aſh decompoſes the ſalts that have lime and magneſia for their baſes, and forms precipitates of calcareous or magneſian arſeniate, in their ſolutions.

12. If we add arſenical acid to the preceding ſalt, till it no longer alters the colour of violets, it ſtill reddens that of turnſole; it yields very regular and tranſparent cryſtals in quadrangular

priſms, terminated by two tetrahedral pyramids, the angles of which anſwer to thoſe of the priſms: this is the *neutral arſenical ſalt* of Macquer. It is this ſalt which is obtained by decompoſing the nitrate of potaſh with the arſenious acid in equal parts; in order to diſtinguiſh it from the preceding, it ought to be termed the acidulous arſeniate of potaſh; it differs from the other not only by its cryſtallizability, but alſo by the circumſtances, that it does not decompoſe the calcareous and magneſian ſalts, as that does; that it reddens the blue colours, and that it is capable of abſorbing a new portion of potaſh, ſo as to paſs into the neutral ſtate. Theſe two ſalts, like all the following, are decompoſed by barites, ſtrontian, lime and magneſia.

13. The arſenical acid, combined with ſoda to ſaturation, forms a ſalt which cryſtallizes like the preceding: Scheele already compared this ſalt with the acidulous arſeniate of pot-aſh. Pelletier ſays, that the arſeniate of ſoda cryſtallizes in hexahedral priſms, terminated by planes perpendicular to their axes. For the reſt, the habitudes of this ſalt are the ſame as thoſe of the arſeniate of potaſh, in its decompoſition by carbon, the acids, and the earths. Scheele remarks, that if we add arſenical acid to it, inſtead of cryſtallizing, it becomes deliqueſcent: this is a property diametrically oppoſite to that which obtains in the arſeniate of pot-aſh.

14. Combined with ammonia, the arſenical acid forms a ſalt which yields rhomboidal maſſes analogous to the cryſtals of nitrate of ſoda. The arſeniate of ammonia, which is alſo the product of the nitrate of ammonia decompoſed by the arſenious acid, is decompoſable in two different ways by the action of caloric. If we heat it gently, the ammonia is diſengaged, and the arſenical acid is left in a pure ſtate. If we expoſe it to a ſtrong and briſk fire, part of the volatile alkali and of the acid mutually decompoſe each other; water is formed, azote gas is diſengaged, and arſenic is ſublimed of a brilliant appearance. Barites, ſtrontian, lime, the two alkalis, decompoſe the arſeniate of ammonia, and ſeize upon its acid. Magneſia decompoſes it in part, and forms a triple ſalt with a portion of this ſalt.

15. The arſenical acid ſaturated with alumine, forms a thick ſolution, which, evaporated to dryneſs, yields a ſalt inſoluble in water, and decompoſable by the ſulphuric, nitric, and muriatic acids, as well as by all the earthy and alkaline baſes. The arſenical acid alſo precipitates none of the aluminous ſalts formed with theſe acids. The arſenical acid, by its fuſion, eaſily diſſolves the alumine of the crucibles; it alſo attacks ſilex; but it effects no alteration in theſe ſubſtances by the humid way. The combination of this acid with zircone is not known.

16. With the aid of a ſtrong heat, the arſenical acid decompoſes the alkaline and earthy ſulphates, even the ſulphate of barites; the ſulphuric acid is diſengaged in the ſtate of vapour, and arſeniates remain in the retort; it acts in the ſame manner upon the nitrates, from which it diſengages the pure acid; at a high temperature, it alſo decompoſes the muriates, diſengaging the muriatic acid in the form of gas; it unites with their baſes, which it ſaturates: this cannot be done by the arſenious acid, for it is too volatile to produce ſuch an effect. It acts in the ſame manner upon the fluates, and with much greater facility upon the carbonates, with which, by heat, it produces a lively effervefcence. It exerts no action upon the phoſphates, and it precipitates the boracic acid from hot ſolutions of the borates.

17. The proportions of the principles of the arſenical acid are hitherto unknown; its reſpective quantities of arſenic and oxigen have not yet been aſcertained, no more than thoſe which compoſe the arſenious acid. However, there is every reaſon to believe, that the firſt contains oxigen in the proportion of at leaſt a ſixth part of its weight, whilſt the arſenious acid perhaps does not contain more than a twelfth.

18. The arſenical acid is not yet applied to any uſe in the arts, at leaſt, not in a direct manner: we ſhall ſee hereafter that it forms an ingredient in certain compoſitions for dyeing; it is alſo one of the mineralizing acids which

nature has combined with ſome metallic oxides. It is prepared in chemiſtry for the purpoſes of experiments and demonſtrations belonging to this ſcience. When its nature ſhall have been better ſtudied, it will, very probably become of great utility in manufactures.

ARTICLE III.

Concerning Tungſten and its Acid.

SECTION I.

Concerning the Metal Tungſten.

A. *Hiſtory.*

1. THOUGH Scheele was the firſt chemiſt who diſcovered and announced the metallic nature of tungſten, (a name at firſt given to a white, very tranſparent mineral, which contains the acidified metal united to lime, and which name was afterwards transferred to the metal itſelf:) though Bergmann in the ſame year 1781, confirmed the diſcovery of Scheele; yet, we muſt refer our firſt knowledge of its metallic properties to Meſſrs. D'Elhuyar, Spaniſh chemiſts, who having diſcovered the ſame metal in the mineral called wolfram, obtained it ſufficiently reduced to exhibit ſeveral of its characters. Since their time, Mr. Angulo has repeated their experiments,

ments, and obtained the ſame reſults at Dijon in the laboratory of the academy.

B. *Phyſical Properties.*

2. The metal hitherto obtained, or tungſten, had the form of a button compoſed of very brittle ſmall globules of the grey colour of ſteel; its ſpecific gravity, 17,6: ſo that it has a denſity intermediate between gold and mercury. It is ſo difficult of fuſion, that it even exceeds manganeſe in this intractability, and conſequently it is, with platina, one of the moſt infuſible of metals. Citizen Guyton has given it the fifth rank for its hardneſs; he places it with zinc as to brittleneſs, and conſequently, according to his ſtatement it is leſs brittle than biſmuth.

C. *Natural Hiſtory.*

3. It has not yet been found native, nor alloyed, nor combined with combuſtibles, nor united with acids; it has only been found in the acid ſtate combined with lime, with iron and manganeſe, and with lead.

4. The firſt of theſe combinations is the tungſten of the Swedes; the ſecond is named wolfram; and the third, the yellow ore of lead. It is more natural to ſpeak at ſome length reſpecting the hiſtory of the tungſtic acid itſelf, which is much more advanced than that of the

metal which compoſes its radical; and alſo its combination with iron and lead.

D. *Aſſay and Metallurgy of the Ores of Tungſten.*

5. The aſſay of theſe ores is made leſs with a view to ſeparate the metal than to prove the preſence of its acid, becauſe the intention of the operator is rather to obtain the acid than the metal. It is uſual, therefore, to treat the metal ſuppoſed to contain native tungſtate of lime with the nitric and muriatic acid; theſe acids, when heated to a certain degree upon this ſubſtance, convert it to a yellow colour, if it contain the tungſtic acid; and it is to this ſimple operation, which in truth, is nothing more than its mineralogical character that the aſſay of this ore is confined.

6. No metallurgic works have yet been carried on with the ores of tungſten. Though ſome of them have been found already in ſufficient abundance, no proceſs has as yet been undertaken, neither in the art of extracting the metal in the large way, which would prove extremely difficult on account of its inſolubility, nor on that of preparing or extracting any uſeful matter from it.

7. In order to obtain the metal in the chemical laboratories, which has not yet been performed, but on a very ſmall ſcale, the tungſtic acid is ſeparated from the ores by the proceſs deſcribed in the next paragraph, then

mixed with charcoal, and urged by heat in a charcoal crucible. A very ſtrong heat is required for its reduction and fuſion; accordingly, this has been effected only in very ſmall quantities.

E. *Oxidability by the Air.*

9. The chemiſts who have hitherto ſpoken of the tungſten metal, agree in conſidering it as very eaſy to be oxided. It is not known, however, whether it burns when expoſed to the air; but when heated with the contact of that fluid, it appears to change very ſpeedily into a yellow oxide, which becomes blueiſh by a ſtronger heat, tinges vitreous fluxes white, or blue, and ſpeedily paſſes to the ſtate of tungſtic acid by a more advanced oxidation. The proportion of oxigen which it abſorbs before it becomes oxided or acidified, has not been determined. Citizen Guyton found that its oxide adheres ſtrongly to vegetable colours, and fixes them.

F. *Union with Combuſtibles.*

9. It is abſolutely unknown whether there be any poſſible combinations between azote, hidrogen, carbon, and the metallic tungſten. Neither are thoſe combinations better known, which, doubtleſs, it is capable of forming with phoſphorus and ſulphur. The ſmall quantities hitherto obtained, have not admitted of trials being made, except with a few of its metallic

alloys, becauſe this kind of attraction has afforded a more eaſy means of its reduction. It is known, that when united with iron and with ſilver, with which it eaſily combines, it changed their properties in a very ſingular manner.

G. *Action upon Water and the Oxides.*

10. NOTHING has yet been done to aſcertain the changes which water and the various oxides might be capable of by tungſten. Nothing, therefore, can yet be aſſumed in this reſpect to characterize this new metal ſo little known, which has hitherto been obtained in a very ſmall quantity: its eaſy oxidability, and its great tendency to become acidified, ſhow, that it would ſeize oxigen from ſeveral other oxides.

H. *Action upon the Acids.*

11. THE firſt, and the only aſſays which have yet been made upon the mutual action of tungſten and the acids, and which are few, as well as moſt of what has been done reſpecting this metal by Meſſrs. D'Elhuyar, ſhow that this metal is inſoluble, and almoſt intractable by the three moſt powerful acids, the ſulphuric, nitric, and muriatic; and that it is only ſlightly attacked by the nitro-muriatic acid.

12. If this ſingular reſiſtance to the ſtrongeſt or moſt decompoſable acids were well founded with regard to tungſten, it would ſhow a reſemblance to gold and platina. Nevertheleſs, I muſt obſerve, that this unchangeableneſs does not agree with what the ſame chemiſts have affirmed reſpecting the oxidability of this metal by the air, aſſiſted by caloric, and conſequently, that it deſerves to be confirmed and eſtabliſhed by new experiments. Nothing has yet been obſerved reſpecting the action of the oxigenated muriatic acid, which acts on the moſt obſtinate metals, and ought by eaſily oxiding this metal to convert it into tungſtic acid.

I. *Action on the Baſes and the Salts.*

13. METALLIC tungſten has not yet been treated by the earthy and alkaline baſes, nor by the ſalts; we may, nevertheleſs, conclude from the action of nitric acid, if not upon the metal, at leaſt, upon its firſt oxide, which it ſpeedily acidifies, that the nitrates and the ſuper-oxigenated muriates, aſſiſted by an elevated temperature, would cauſe it to paſs to the ſtate of acid; and that performed, would afford tungſtates as the reſults of this action.

K. *Uſes.*

14. NOTHING has yet been obſerved reſpecting the uſes of a metal ſo little known or examined as tungſten. No trial has yet been made with regard to its uſeful properties. We may even fear, that its reduction and fuſion being ſo difficult, would render it ſo intractable as not to be uſed but with great difficulty.

Nevertheleſs, it is proper that we ſhould indulge in the hope that the arts being at ſome future period directed to this metal ſtill ſo new, and of which nature offers ſo abundant a quantity in the ore called wolfram, may diſcover proceſſes of greater ſimplicity than thoſe we yet poſſeſs to obtain the metal in the large way; and we may indulge an expectation at the ſame time, that this metallic ſubſtance may become very uſeful in many operative proceſſes. This concluſion very naturally preſents itſelf from the few properties already diſcovered in tungſten, namely, its conſiderable hardneſs, its partial ductility, in which it approaches to zinc, its infuſibility, even its unchangeableneſs by acids, and the property of its oxide to unite with vegetable colouring matters, to render them fixed and not liable to change. Chemiſts ought, therefore, to redouble their efforts in the examination of this metal, of which the hiſtory muſt be conſidered as ſcarcely brought to an outline. We ſhall find, that the acid has been much more attentively examined.

SECTION II.

Concerning the Tungſtic Acid.

1. AS Scheele and Bergmann, in their examination in 1781 of the heavy ſtone or tungſten of the Swedes, diſcovered that it is compoſed of lime, ſaturated with a peculiar acid: as their diſcovery has ſince been confirmed by various chemiſts, and particularly much extended by the reſearches of Meſſrs. D'Elhuyer, which by ſhowing the preſence of this acid in wolfram, has afforded means to chemiſts of procuring it more abundantly; it is not aſtoniſhing, that the properties of the acidified tungſten ſhould have been much more ſtudied than the metallic tungſten, and that we ſhould poſſeſs a greater maſs of knowledge reſpecting the one than the other.

2. It was very natural to deſignate this acid by the name of tungſtic, after the Swediſh word, which repreſents its native combination with lime. In the French nomenclature the G is expunged from the word, to render the pronunciation more ſoft and eaſy.

3. This acid is not artificially compoſed, becauſe nature preſents it in the tungſtate of lime and of iron. The firſt is treated by reducing it

to very ſine powder, diſſolving the lime by the nitric or muriatic acid, and afterwards with alkalis, which diſſolve the acid: the alkaline ſolutions of the tungſtates are precipitated by the nitric or muriatic acid; and this precipitate is the ſolid tungſtic acid which is kept to be formed into new combinations. It may be extracted from the native tungſtate of lime, in the quantity of 0, 68.

4. The tungſtic acid may alſo be obtained from the tungſtate of lime by another proceſs, for which we are indebted to Scheele, as well as for the foregoing. It conſiſts in fuſing in a crucible, one part of tungſtate of lime with four parts of carbonate of pot-aſh: the latter unites with the tungſtic acid, while the carbonic acid ſeizes the lime; ſo that the product of this fuſion is a mixture of tungſtate of pot-aſh which is ſoluble, and of carbonate of lime. This maſs is lixiviated with twelve parts of boiling water, and upon the ſolution nitric acid is poured, and the precipitated acid is afterwards well waſhed. The reſidue of the aqueous ſolution contains carbonate of pot-aſh and tungſtate of lime, not yet decompoſed. The former is ſeparated by nitric acid, and the undiſſolved portion is again treated with four parts of carbonate of pot-aſh. In this manner an exact analyſis of native tungſtate of lime may be made.

5. In order to extract the tunſtic acid from the tungſtate of lime and native mangaueſe, this ore is mixed in powder with two or three times

its weight of nitrate of pot-aſh. This mixture is detonated by projecting it, a ſpoonful at a time, into an ignited crucible, or by heating it in a veſſel ſufficiently large to prevent its boiling over. When the detonation is finiſhed, the matter is lixiviated in diſtilled water, which diſſolves the tungſtate of pot-aſh thus formed, and from this ſolution the tungſtic acid is precipitated in the form of a white powder, by an exceſs of muriatic acid, and this powder muſt be waſhed with water till the fluid comes off taſteleſs. The latter preparation is rather more difficult, and frequently affords an acid rather leſs pure, than the former; but by treating it with the muriatic acid, it may be deprived of all its mangaueſe and iron, and reduced to a very white and pure ſtate. The abundance of tungſtate of iron in France, where the tungſtate of lime has not yet been found, muſt engage the French chemiſts to bring theſe proceſſes for extracting the tungſtic acid to perfection. It contains it in the proportion of 0,64.

6. The tungſtic acid thus prepared, has the form of a white powder, of a ſharp metallic and weakly acid taſte. Its ſpecific gravity indicated by Bergmann, is 3, 600. It reddens the tincture of turnſole.

7. When heated by the blow-pipe, the tungſtic acid firſt becomes yellow, then brown, and at laſt black. It emits no fumes, nor does it exhibit any ſign of fuſion. When it is calcined

for a time in a crucible, it loſes its quality of being diſſolved in water.

8. It undergoes no perceptible change in the air. It is ſoluble in twenty parts of boiling water, and a portion ſeparates by cooling. This ſolution is ſour and reddens the tincture of turnſole.

9. When heated with charcoal it paſſes again, though with difficulty, to the metallic ſtate: with ſulphur it becomes grey, without reduction, as is alſo the caſe with phoſphorus. It precipitates the alkaline ſulphurets of a green colour. It appears to be decompoſable by various metals; for if a ſmall quantity of muriatic acid be added to its ſolution in water, and a few drops be laid upon a poliſhed plate of zinc, tin, or iron, it leaves a blue ſpot. The ſame blue colour is manifeſted when thoſe metals are plunged in its ſolution.

10. The acids do not diſſolve the white and pulverulent tungſtic acid, but they alter its properties in a remarkable manner, which is not yet well underſtood. The boiling ſulphuric acid renders it blue, in which property it reſembles the molybdic acid; the nitric and muriatic acids cauſe it to aſſume a fine yellow colour. In this laſt ſtate the tungſtic acid, according to the obſervation of Meſſrs. D'Elhuyar, loſes its taſte, its ſolubility, and acquires, with a much greater ſpecific gravity, the property of forming with the baſes, ſalts, which are different

from thoſe of the white acid. The Spaniſh chemiſts were of opinion, that the white acid before deſcribed, is a triple acidulous ſalt, and that the yellow is the pure tungſtic acid. But there is one obſervation which proves, that in this yellow ſtate it has loſt its four taſte, contrary to the firſt aſſertion, which is not in other reſpects ſupported by ſufficient experimental proofs. The yellow colour which the tungſtic acid aſſumes with the nitric and muriatic acids, is one of its moſt evident ſpecific characters.

11. The tungſtic acid, forms with barites an inſoluble ſalt, as well as with magneſia. When its ſolution is thrown into lime-water it affords a precipitate of tungſtate of lime, ſimilar to that found in the native ſtate, and as inſoluble. With pot-aſh a ſalt is obtained which affords very ſmall cryſtals ; tungſtate of ſoda has not yet been deſcribed or announced. When ſaturated with ammonia the tungſtic acid forms a ſalt which cryſtallizes in very ſmall needles, from which the volatile alkali eſcapes by the action of fire. It changes into a dry yellowiſh powder ; the ammoniacal tungſtate decompoſes the nitrate, and the muriate of lime, and precipitates them in the form of inſoluble tungſtate of lime. Its combinations with alumine and zircone have not yet been examined.

12. The tungſtic acid does not precipitate or decompoſe the ſalts, but by double elective attraction. The ſolutions of the alkaline tung-

ſtates form in this manner precipitates of earthy tungſtates in the ſolutions of the ſulphates, nitrates, and muriates of lime, alumine, magneſia, and barites. It melts with the phoſphates and borates, to which it gives a white or a green colour.

13. It does not act as a ſolvent on the metals; nevertheleſs it oxides iron, by giving out its oxigen, and becoming blue.

14. It is not yet of any uſe. Citizen Guyton has already propoſed means of rendering it uſeful by uniting it to vegetable colouring matters, which it has the property of fixing and rendering ſolid. We ſhall again treat of this property.

ARTICLE IV.

Concerning Molybdena and its Acids.

SECTION I.

Concerning the Metal Molybdena.

A. *Hiſtory.*

1. THE name of molybdena which was formerly ſynonymous with that of plumbago or black lead, or the natural combination of iron and charcoal, or carburet of iron, elſewhere

where to be treated of, is at preſent given to a brittle and acidifiable metal of which the ore was confounded with that coaly ſubſtance. Though Pott, Quiſt, and ſome other chemiſts, originally pointed out ſome differences in the properties of the ore of molybdena, and the carburet of iron, moſt naturaliſts had not ſufficiently diſtinguiſhed theſe two ſubſtances. Many conſidered them as one and the ſame ſubſtance, and they were ſold under the ſame denomination till Scheele, in 1778, publiſhed in the volumes of the Stockholm academy a memoir in which he ſhowed that the ſubſtance called molybdena is very different from the carburet of iron, and contains a combination of ſulphur, with a ſubſtance which he took for a peculiar acid. Pelletier ſince repeated all his experiments, and added many others, in a memoir publiſhed in the Journal de Phyſique 1789, in which he proves that the molybdena of the mineralogiſts is a combination of a peculiar Metal and ſulphur, and that by treating it in ſeveral different methods, all of which ſeparate the ſulphur and oxigenate the metal, Scheele had formed and not obtained the acid. At the ſame time he not only confirmed the diſcoveries of Scheele reſpecting the molybdic acid, but he pointed out many of its properties which had eſcaped the Swediſh chemiſt. Since theſe experiments which have been admitted and verified by all chemiſts the metal has been named molybdena; in the methodical nomenclature its ore is called ſulphuret of molybdena, and its acid, the molybdic acid.

B. *Phyſical Properties.*

2. THE metal molybdena is extremely rare, and very difficult to be obtained. As in ſeparating the ſulphur from its ore it oxides, and very eaſily becomes acidified, it is neceſſary afterwards to decompoſe its acid, and deprive the metal of its oxigen. Scheele when he made this experiment with great care uſing various ſolvents, never could ſucceed in obtaining it in the metallic ſtate, the reſults of his operations having been only a black powder without coherence, and without brilliancy. Bergmann in 1781, in his diſſertation on the metallic acids announced and wrote the ſame year to Citizen Guyton, that Doctor Hielm, formerly his pupil had ſucceeded in reducing this acid, and collecting a ſufficient quantity of metallic molybdena to aſcertain its true character; but ſince this notice nothing has been publiſhed, neither on the proceſs of Hielm, nor the metal obtained by his experiments. Pelletier, in his experiments on the reduction of the oxides and acid of molybdena did not obtain a metallic bottom, but an agglutinated, blackiſh, friable maſs, poſſeſſing the metallic brilliancy, in the fracture of which ſmall round brilliant greyiſh grains are diſcernable; this metal ap-

pears to be extremely infuſible; its ſpecific gravity is about 6,000.

C. Natural Hiſtory.

3. Molybdena has not yet been found except in the ſtate of ſulphuret and that of acid. As in this latter ſtate it is found in the form of ſalts combined with the metallic oxides, it muſt be treated under thoſe metals with the oxides of which it is found combined.

4. The ſulphuret of molybdena, which has long been confounded, as before noticed, with the carburet of iron, differs nevertheleſs from it in many reſpects. It is leſs greaſy to the touch, more hard, leſs granulated, more brilliant, leſs dull, and conſiderably more inclining to blue. As it is formed of large ſcaly plates, lying one upon another, with little adheſion, which may be ſeparated from each other, or even cut with a knife, it ſoils the fingers leſs than the carburet of iron, and leaves upon paper blueiſh, or ſilvery-grey traces, leſs deep and coloured than thoſe of plumbago. It is difficult to pulverize on account of the elaſticity of its plates. Scheele ſucceeded in this operation by adding cryſtallized ſulphate of pot-aſh to it in the mortar, which he afterwards waſhed off; its powder is blueiſh. Citizen Haüy adds to its diſtinctive characters the following properties: the ſulphuret of molybdena communicates to reſin the vitreous elec-

tricity by friction, whereas the carburet of iron communicates none, at leaſt, when its metallic mark is left. It forms on pottery ſtrokes of a yellowiſh green, whereas thoſe from the carburet of iron have its ordinary colour. M. Kirwan eſtimates that the proportions of the component parts of ſulphuret of molybdena are 0,55 of ſulphur, and 0,45 of metal.

5. As chemiſts have examined the ſulphuret of molybdena much more than the metal itſelf, I am obliged in each of the following numbers to point out the few notions I have been able to collect reſpecting molybdena, and the alterations which its ſulphuret undergoes by each agent. For want of information reſpecting the metal, I ſhall, in a certain manner, fill the vacancies of its hiſtory by announcing the properties of ſulphuret of molybdena; and I ſhall obſerve in this reſpect that, by ſeparating the effects manifeſtly due to the ſulphur of which I ſhall ſpeak, the others are really phenomena, owing to the metal itſelf.

D. *Aſſay and Metallurgy.*

6. The ſulphuret of molybdena may be diſtinguiſhed manifeſtly, and without error, after having aſcertained the phyſical properties before deſcribed, together with that when treated by the blow-pipe, it emits ſulphur, diſtinguiſhable by its ſmell, and white fume, which condenſes upon the neighbouring cold bodies in

plates or cryſtallized needles, of a yellowiſh flame, which becomes blue by contact of the interior flame.

7. The ſulphuret of molybdena is not treated in the large way, as its only uſe is occaſionally in its native ſtate, or pulverized, inſtead of carburet of iron, the true purpoſe of which it never anſwers.

E. *Oxidability by Air.*

8. Molybdena, heated with the contact of the air, is changed at an elevated temperature into a white volatile oxide, cryſtallized in brilliant needles, which ſpeedily acquire the acid properties, The proportion of oxigen which this metal abſorbs in its oxidation has not yet been determined This oxide, heated with combuſtible bodies, aſſumes a dark blue colour, of little brilliancy, approaching towards the metallic ſtate.

9. The ſulphuret of molybdena, calcined in a large crucible, covered with a veſſel of the ſame kind, afforded Pelletier white brilliant needles, which riſe in ſublimation like thoſe of antimony, and which he found to poſſeſs acid characters. Sulphur was diſengaged before this matter ſublimed.

F. *Union with Combuſtible Bodies.*

10. Molybdena unites very well with ſulphur by heat, and again forms the ſulphuret of molybdena. Its union with phoſphorus is not known. It unites with the metals, and renders them granulated, greyiſh, and very friable.

G. *Action of Water and the Oxides.*

11. The action of molybdena, or its ſulphuret, upon water and the metallic oxides, is unknown.

H. *Action of Acids.*

12. The action of molybdena on the various acids has not yet been appreciated. It is only known that boiling ſulphuric acid oxides it, and the nitric acid converts it into molybdic acid.

13. Scheele and Pelletier have better determined the actions of ſome of the acids upon the ſulphuret of molybdena. The boiling ſulphuric acid affords ſulphureous acid, and oxides the metal. The nitric acid diſtilled from this ſulphuret burns the ſulphur, and acidifies the metal. Scheele, by treating one part of the ſulphuret of molybdena five ſucceſſive times, with ſix parts of nitric acid, a little diluted with water each time, obtained in the retort a white powder, which was a mixture of ſul-

phuric acid and molybdic acid. The muriatic acid has no action either on the metal or its ore. The arſenic acid, heated in the retort with ſulphuret of molybdena, burns the ſulphur into ſulphureous acid, converts a portion of the metal into the molybdic acid, leaves another portion in the ſtate of metal, and itſelf becomes converted partly into metal and partly into ſulphuret of arſenic. Pelletier made uſe of this experiment to prove that molybdena poſſeſſes the metallic ſtate in its ore.

SECTION I.

Action on the Salifiable Baſes and the Salts

14. THE alkalis diſſolve molybdena, and favour its oxidation, which, in general, is very eaſy. By means of fire, in the dry way, they form with the ſulphuret of molybdena an alkaline ſulphuret, which retains the metal in ſolution. This action has been little examined, and the effect of the earthy matters on molybdena, or on its ore, has not at all been inquired into.

15. Among the ſalts there is only the nitrate of pot-aſh, of which the mode of action upon ſulphuret of molybdena has been determined; but its effect on the metal is ſtill unknown. One part of this ore, and four parts of nitre, detonate in a crucible at a red heat, and afford a reddiſh

a reddiſh maſs. This maſs by lixiviation leaves about 0,02 of red oxide of iron, and affords in the ſolution ſulphate of pot-aſh, undecompoſed nitre, and molybdate of pot-aſh, which prove that the ſulphur and the molybdena, both being oxigenated to their maximum, or acidified, have united with the baſe of nitre.

K. *Uſes.*

16. As we have hitherto obtained but a ſmall portion of molybdena, it has not yet been treated, except ſlightly, in the way of chemical examinations; it has not been applied to any uſe. The ſulphuret of molybdena is ſometimes ſubſtituted in the arts for the carburet of iron, with which it is confounded in commerce; but, as has been before obſerved, it anſwers the purpoſe of that ſubſtance very imperfectly; ſo that we may affirm, that its uſes are yet unknown. When it ſhall be more correctly examined, and its properties rendered more familiar, it is not improbable but that it may enter into ſome alloys, and that its blue or yellow oxide may be uſed as a pigment.

SECTION II.

Concerning the Molybdic Acid.

1. WE have already ſeen that we are indebted to Scheele for the diſcovery of the molybdic

acid; but it may at the ſame time be remarked, that though this ſkilful chemiſt was the firſt who prepared the acid, its diſcovery was really contaminated by an error, ſince he ſuppoſed that he had ſimply extracted the molybdic acid from its ore, which is ſtill called molybdena by all mineralogiſts; and ſince he conſidered this ore as a true compound of the acid with ſulphur and a ſmall quantity of iron. The doctrine of the French chemiſts has aſcertained and corrected this error, by ſhowing to Citizen Guyton, to Pelletier, and to all the authors or partiſans of the pneumatic theory, that in the various experiments of Scheele, in which he obtained the molybdic acid, he really produced or formed it by burning the molybdena, and charging it with the whole quantity of oxigen it was capable of abſorbing.

2. Though the molybdic acid appears to exiſt in nature, as Mr. Klaproth has obtained it from yellow lead ore, it has always been prepared or fabricated artificially, by treating the ſulphuret of molybdena, the only ore of this ſubſtance yet known, by ſeveral oxigenating proceſſes.

3. There are four proceſſes known and practiſed to convert the molybdena contained in its ore or native ſulphuret, into molybdic acid. The firſt conſiſts in its oxidation by fire and air. Scheele had obſerved, that when a fragment of ſulphuret of molybdena is heated in the flame of the blow-pipe upon a plate of ſilver, the white fume which it emits attached it-

ſelf to the plate in a thin ſcale of a yellowiſh brilliant white, which was the true molybdic acid. But this method produced only a few particles. Pelletier has greatly extended it by directing that the ſame operation be made in a crucible covered with another veſſel of the ſame kind. The white brilliant priſms which ſublime in this experiment, are the molybdic acid. But this method is tedious, requires ſtrong heat, and does not afford very pure acid, It is not therefore to be preferred.

4. The ſecond proceſs is performed with nitric acid, and is one of the moſt certain. Upon one part of the ſulphuret of molybdena, five parts of this diluted acid are to be poured; the diſtillation is then to be carried on to dryneſs, and a mixture of nitrous gas and nitrous vapour is obtained with much froth; this diſtillation is to be repeated three or four times, employing five parts of the ſame acid every time. At the end, the dry reſidue is as white as chalk, and conſiſts of the molybdic acid mixed with the ſulphuric acid. The nitric acid has burned the ſulphur, and acidified the molybdena by yielding its oxigen to it, and decompoſing it. The dry reſidue is to be waſhed with hot water, by which means the molybdic acid is obtained pure and concrete. The water made uſe of, carries off a ſmall portion of this acid, together with the ſulphuric acid; and when it is ſtrongly evaporated, it aſſumes a blue colour which an-

nounces the decompoſition of its acid, and its tranſition to the metallic ſtate.

5. In the third proceſs, the ſulphuret of molybdena is diſtilled with the arſenic acid. There is no action between theſe two bodies while any water is preſent; but when the water is paſſed over and the fire is raiſed, arſenic and the ſulphuret of arſenic ſublime; the ſulphureous acid paſſes over, and the concrete molybdic acid remains in the retort. But this acid is not pure; it is mixed with arſenic and ſulphuret of arſenic.

6. The fourth proceſs is the moſt expeditious of all, and would deſerve to be preferred to them if it afforded the acid in a ſtate of purity. It is the product of the detonation of nitre with the ſulphuret of molybdena. Three parts of nitrate of pot-aſh, and one part of ſulphuret of molybdena, well pulverized and well mixed together, are thrown into an ignited crucible, After the detonation, the reſidue is a reddiſh maſs compoſed of the oxide of iron, ſulphate of pot-aſh, and molybdate of pot-aſh. By lixiviating it in water the two ſalts are diſſolved, and the oxide of iron remains. The ſolution is evaporated to obtain ſulphate of pot-aſh, and ſulphuric acid is poured into the liquor which refuſes to cryſtallize, and which muſt be diluted with a ſmall quantity of water, until by the addition of more acid, no further perceptible precipitate falls down. We muſt, nevertheleſs obſerve, that this acid does not com-

pletely decompoſe the molybdate of pot-aſh, and that the acid which falls down is the acidulous molybdate of pot-aſh, of which the properties eſſentially differ from the pure molybdic acid. I have deſcribed this proceſs merely to ſhow the particular reſult and the exiſtence of this molybdic acidule. We muſt conclude, that the true and the only means of obtaining the pure molybdic acid conſiſts in the ſecond proceſs, or the treatment of ſulphuret of molybdena by the nitric acid.

7. The molybdic acid prepared by the operations before pointed out, particularly by the ſecond proceſs, is a white powder, of a ſharp metallic taſte. Its ſpecific gravity, according to Bergmann is 3,400.

8. When heated in a large glaſs retort it affords, by a ſtrong fire, a ſmall quantity of ſulphureous acid, which proves that it cannot be deprived of that acid but with the greateſt difficulty. But it undergoes no other alteration by this treatment than a commencement of fuſion. In a well-cloſed crucible it is fuſed by a ſtrong heat, adhering to the ſides of the veſſel in a glaſſy covering; and it cryſtallizes in red radii, which iſſue from the centre by the cooling. If the crucible be uncovered at the moment of fuſion, it riſes in a white fume by contact of the air, and this vapour attaches itſelf in brilliant ſcales of a golden-yellow colour upon the ſurrounding cold bodies. This fume diſappears, and the volatilization ceaſes the moment the apparatus is cloſed:

cloſed : hence it follows, that the contact of the air is the immediate cauſe, and therefore, there is no ſublimate according to Scheele, found in the crucible which ſerves as a cover. It appears, either that Scheele did not apply ſufficient heat, or that a ſmall quantity of air introduced itſelf into the experiment of Pelletier. His ſulphuret of molybdena was burned and acidified.

9. Moſt combuſtible bodies decompoſe the molybdic acid. Carbon reduces it by the aſſiſtance of heat into a black powder which approaches the metallic ſtate, and wants only the aggregation by fuſion to be true molybdena. By heating with three parts of ſulphur, there is a diſengagement of ſulphureous acid, and ſulphuret of molybdena is formed. Several metals heated with this acid, alſo reduce it, themſelves becoming partly oxided, and partly combined in alloys with the molybdena.

10. Hot water eaſily diſſolves it ; one part of this acid requires about five hundred parts to diſſolve it ; this ſolution is very acid and ſharp ; it reddens turnſole, precipitates the alkaline ſulphurets, and decompoſes ſoap. After its fuſion, it is equally ſoluble, in which reſpect, it differs from the tungſtic acid. The ſolution of the molybdic acid becomes blue when iron or tin are kept plunged in it ; it efferveſces with the alkaline carbonates ; it precipitates the ſolutions of nitrate, of muriate, of barites. The molybdic acid becomes much more ſolu-

ble with a ſmall portion of alkali, by forming acidulous molybdate.

11. The concentrated ſulphuric acid diſſolves much molybdic acid by the aſſiſtance of heat; it becomes violet and blue as it cools. The muriatic acid alſo diſſolves a great quantity by ebullition. By diſtilling to dryneſs, a part of the acid ſublimes of a blue and white colour. The reſidue is grey and deliqueſcent, like the ſublimate. The ſame phenomenon is ſeen even in the fume of molybdena produced by the blow pipe, for the interior flame colours thoſe fumes blue. The nitric acid does not affect the acid of molybdena.

12. The molybdic acid eaſily unites with the alkaline and earthy baſes, and forms ſalts of ſparing ſolubility with the latter, but very ſoluble and cryſtallizable with the alkalis. Scheele has ſaid very little concerning the properties of the alkaline and earthy molybdates, which are ſtill almoſt entirely unknown. The calcareous molybdate is not rendered yellow by the nitric acid. The molybdate of barites is ſomewhat ſoluble in water; the ammoniacal molybdate is decompoſable by fire. There is an acidulous molybdate of pot-aſh; and Scheele, without denoting it by a particular name, points out, nevertheleſs, its characters different from thoſe of the pure molybdic acid. I ſhall diſtinguiſh it here on account of its differences, and becauſe, it is frequently obtained inſtead of the pure acid.

13. The acidulous molybdate of pot-aſh, is obtained either by precipitating the product of the detonation of nitre and ſulphuret of molybdena by the ſulphuric acid, or by directly uniting molybdic acid with a ſmall quantity of pot-aſh, as if to render it more ſoluble. This ſalt affords ſmall irregular cryſtals by cooling its ſaturated boiling ſolution; the acid which is greatly in exceſs, is not, however, volatile by an open fire, as it is when alone. The acidulous molybdate of pot-aſh is much more ſoluble than the molybdic acid, ſince it requires only four parts of boiling water; it is alſo more fuſible. It may be decompoſed by throwing into its hot concentrated ſolution a ſmall quantity of nitric acid, which retains its alkali, and precipitates the molybdic acid in ſmall cryſtals. The ſame acidule does not decompoſe the ſulphate of pot-aſh by the aſſiſtance of fire, like the pure acid.

14. The molybdic acid ſtrongly heated with moſt of the ſulphates, and particularly with that of pot-aſh, diſengages a ſmall portion of ſulphuric acid, becauſe it forms in this caſe the acidule of molybdena; accordingly, the ſulphuric acid does not decompoſe the molybdate of pot-aſh, but to the point of producing the ſame acidule, as I have already remarked. It likewiſe decompoſes the nitrates, and diſengages the nitrous acid by heat. The muriates are alſo decompoſed, and a portion of the white, yellow, or violet molybdic acid ſublimes, which attracts

moiſture, is reſolved into a fluid in the air, and becomes blue on the metals. Theſe two decompoſitions of the nitrates and the muriates, the nitrous acid which is diſengaged from the former, and the deliqueſcent ſtate of a portion of molybdic acid, ſeem to announce that it is capable of becoming ſurcharged with oxigen, receiving modification by this ſuper-oxigenation; nevertheleſs, it appears to ſuper-oxigenate the muriatic acid which is diſtilled from it, ſince it becomes blue by this action. Further experiments are wanting on this point.

15. The molybdic acid is not yet of any uſe; it has hitherto been only an object of reſearch and curioſity with chemiſts. The example of the tungſtic acid, of which Citizen Guyton has already determined a uſeful property for dyeing, ought to engage chemiſts to attend to the molybdic acid under the ſame point of view.

ARTICLE V.

Concerning Chrome and its Acid.

SECTION I.

Of the Metal Chrome.

A. *Hiſtory.*

1. THE analyſis of a mineral made by other means, and with more care than hitherto had been applied to its examination, preſented in

December, 1797, to Citizen Vauquelin, the diſcovery of this new metal. The red lead of Siberia appeared to him, from ſeveral previous examinations, to offer properties, which he had not obſerved in any other ſubſtance. After having made a ſeries of experiments upon this ore, which, unfortunately, is very ſcarce, and little abundant in our cabinets, he aſcertained, that it is formed of oxide of lead and 0,36, of a new acid which Bindheim, and ſeveral other chemiſts took for molybdic acid, but, which differs greatly from it, inſtead of reſembling its properties, as we ſhall ſpeedily ſee. The following is the account of its diſcovery:

2. By treating the Siberian red lead with two parts of carbonate of pot-aſh diſſolved, which he boiled in two hundred parts of water, the pot-aſh ſeized the new acid while the carbonic acid united with the lead. The new ſalt was found in ſolution in the water, and the carbonate of lead at the bottom in the form of white powder. He precipitated the acid of the new ſalt by means of nitric acid, which ſeized the pot-aſh. The red lead of Siberia, when treated with the muriatic acid, was totally diſſolved, aſſuming a beautiful deep red colour; the liquor by evaporation, afforded muriate of lead; the ſupernatant fluid which preſerved its fine green colour, contained the oxide of the new metal diſacidified by the muriatic acid, and having, by that means, paſſed from the orange-red colour to green.

B. *Phyſical Properties.*

3. THE acid obtained by the firſt proceſs, and the oxide produced by the ſecond, were both reduced by Citizen Vauquelin, by ſtrongly heating them in a crucible of charcoal; he obtained a metal different from all thoſe yet known, which we have agreed to name chrome, on account of its remarkable property of forming a very coloured acid, and itſelf giving colour to all its ſaline combinations.

4. Since this firſt diſcovery, Citizen Vauquelin has found this metal, 1ſt. In a green oxide united to lead in cryſtals of the ſame colour, which are almoſt always found in the ſame locality as the Siberian red lead. 2dly. Alſo in a green oxide in the emerald of Peru, of which it is the true colouring matter. 3dly. In the acid form in the ſpinelle ruby, to which it gives the beautiful red tinge it poſſeſſes. M. Taſſaert, a Pruſſian chemiſt, who is charged with the operations of the laboratory of the ſchool of the mines at Paris, has ſince found the chromic acid combined with iron in an ore of the department of Var, near Toulon.

5. The metal extracted by this proceſs, is of a white colour inclined to grey, very hard, very brittle, and extremely difficult of fuſion. The ſmall quantity which Citizen Vauquelin could procure, did not permit him to aſcertain many of its properties.

C. *Natural Hiſtory.*

6. In the hiſtorical notice of its diſcovery, we have ſeen that it is already known in two ſtates, and in four foſſils ; in green oxide united to oxide of lead, and the emerald of Peru ; in red acid, combined with the oxide of lead in the red lead of Siberia; and with alumine in the ſpinelle ruby. There is no doubt, but it will ſoon be found either in other ſtates, or combined in many more minerals.

D. *Docimaſy and Metallurgy.*

7. By deſcribing the manner of its diſcovery, and the proceſſes by which it was obtained, we have pointed out every thing which can appertain to the method of aſſaying its mineral. There is nothing more to be added reſpecting the metallurgical works, to which it may give riſe, ſince its diſcovery, in three or four very ſcarce foſſils, cannot have enabled any operators yet to ſubject it to any works in a large way.

E. *Oxidability by the Air.*

8. Nothing is yet known reſpecting its oxidability by the air.

F. *Union with Combuſtibles.*

9. The ſame remark may be made reſpecting its combination with combuſtible bodies. The very ſmall quantity yet ſubjected to experiment, rendered it impoſſible to unite it with ſulphur or with the metals.

G. *Action upon Water and the Oxides.*

10. It has not yet been aſcertained whether it be capable of acting upon water, what may be its attraction by oxigen, and its habitudes with the different oxides. It appears, that it has very little action in theſe circumſtances, as it is very eaſily diſoxided, and does not oxide but with great difficulty.

H. *Action upon the Acids.*

11. Though it is obtained in very ſmall quantity, Citizen Vauquelin has, nevertheleſs, been able to aſcertain its action on ſome of the acids. He has found, that it is not attacked by the ſulphuric or the muriatic acids; that nitric acid, diſtilled ſeveral ſucceſſive times upon it to dryneſs, changes into a green oxide, and even cauſes it to paſs to the ſtate of yellow orange chromic acid; that the nitro-muriatic acid particularly produces this effect with much more

ſpeed, and that it may, by that means, be made to acquire all the properties it poſſeſſes in the Siberian red lead.

I. *Action upon the Baſes and the Salts.*

12. It is entirely unknown whether it is capable of alteration by the earths and alkalis; it does not eaſily unite with them, unleſs in the ſtate of acid, for in that of green oxide it is not ſoluble. This green oxide is even obtained by the cauſtic fixed alkalis, by ſeparating it from the alumine with which it is united in the emerald, to which alumine the alkalis unite without touching the oxide of chrome.

13. We are not at all acquainted with its action on the ſalts.

K. *Uſes.*

14. It is hardly to be imagined, that ſo recent a diſcovery can have yet been applied to any uſe. Nevertheleſs, its author has already obſerved, that its oxide may be uſed in the fabrication of glaſs and enamel, and it may even, perhaps, have been already employed without ſuſpecting it, in the mixtures of the products of minerals ill underſtood or analyzed, of which it may form a part. The manufacturers of porcelain are often in this ſituation, when they prepare oxides from very mixed ores in order to obtain variety of ſhades. The nature of theſe

ſhades depends on unknown alloys, of which the chrome may well be one of the conſtituent parts.

SECTION II.

Concerning the Chromic Acid.

1. THOUGH the chromic acid has been very lately diſcovered, and has not yet been examined, except in very minute quantities, by the different proceſſes to which Citizen Vauquelin has ſubjected it, it is nevertheleſs better known, and affords more facts to the hiſtory of chemiſtry than chrome itſelf. This ariſes from its being found native in combination with the oxide of lead, ſo that it was much more eaſy to extract it and aſcertain ſome of its properties, than to perform the ſame with regard to the metal which has not yet been obtained, except with the greateſt difficulty, and in much leſs quantity.

2. The chromic acid extracted from the red lead of Siberia, treated by the carbonate of pot-aſh, and diſengaged from this alkali by a ſtronger acid, has the form of a red or yellow orange powder, of a peculiarly ſharp metallic taſte, more perceptible than that of any other metallic acid.

3. When expoſed to the action of light and caloric in open veſſels, it becomes green; in cloſe veſſels it affords pure oxigen, and paſſes to

the ſtate of green oxide by loſing its acidity. The red lead of Siberia itſelf gives out oxigen gas, when heated in cloſe veſſels, and aſſumes a yellowiſh-green colour. The chromic acid is the firſt metallic acid known which is capable of diſacidifying itſelf ſo eaſily by the action of caloric, and affording oxigen gas by this ſimple operation. We ſhall ſee, that many of its properties depend on the ſlight adherence, at leaſt, of a portion of its oxigen. The green oxide of chrome paſſes again to the ſtate of chromic acid only, when treated by the acids which reſtore its oxigen.

4. The action of moſt of the combuſtible bodies on the chromic acid, is yet unknown. It is only known, that when ſtrongly heated with charcoal it becomes black, and ſoon paſſes to the metallic ſtate without fuſion; the facility with which it permits its oxigen to eſcape, ſhows that it may be decompoſed by hidrogen, phoſphorus, and ſulphur.

5. The chromic acid is ſoluble in water, and cryſtallizes by cooling and evaporation, in priſms of a ruby-red colour. It appears to be capable of uniting with many metallic oxides.

6. Among the acids, none has a more remarkable action upon it than the muriatic. When this acid is diſtilled by gentle heat from the chromic acid, the latter paſſes ſpeedily to the ſtate of oxigenated muriatic acid; conſequently, it acquires by this mixture, the property of diſſolving gold. By this property it reſembles the nitric

acid, in conſequence of the weak adherence of its oxigen. It muſt be remarked, that it is the only one of the metallic acids which exhibits this character.

7. The chromic acid unites very eaſily with alkaline matters. It forms with them ſolutions of an orange or yellow colour, which afford orange cryſtals by evaporation. It is the only acid which has the property of colouring its ſalts; which circumſtance has induced us to denominate it the chromic acid, preſerving the name of chrome from its metallic radical. We are not yet acquainted with the earthy chromates, nor with the ſpecific properties of the alkaline chromates, nor the order of attraction of the acid for its baſes. We only know that the earthy chromates are inſoluble, or much leſs ſoluble than alkaline chromates.

8. We are equally unacquainted with the action of the chromic acid upon the ſalts, whether it be capable of decompoſing ſome of them, as we have ſeen in the other metallic acids. It appears, at leaſt, that this decompoſition cannot operate but by virtue of a very elevated temperature, or the double elective attractions, ſince the ſulphuric, nitric, and muriatic acids, decompoſe the chromate of pot-aſh, and precipitate the chromic acid from its ſolution.

9. As the action of the chromic acid upon the metals has not yet been appreciated, I can ſay nothing of its combination with arſenic, tungſten, and molybdena, nor of the order of

the attractions between this acid and thoſe of the metallic radicals, of which the order of the preſent work would otherwiſe require me to treat in this place. The chromic acid, as well as the green oxide of chrome, promiſes to be very uſeful, either alone or combined with the other metallic oxides, to painters, enamellers, glaſs-makers, in the imitation of precious ſtones, and, perhaps, even in dyeing.

ARTICLE VI.

Concerning Titanium.

A. *Hiſtory.*

1. IN 1795, the third year of the French republic, Mr. Klaproth, a chemiſt of Berlin, having examined a foſſil from Boinik in Hungary, known by the name of red ſchorl, on account of its priſmatic or fluted columnal form, diſcovered that it was the native oxide of a metal till then unknown. He characterized it by the following properties, which are in fact, the moſt marked and the moſt diſtinctive of any it poſſeſſes. By calcination, it paſſes from white to yellow, and from yellow to red; it affords a yellow enamel, aſſumes blue, yellow, and violet colours, by the vitreous fluxes before the blow-pipe; is very greedy of oxigen; is precipitated by the ſulphurets; affords a thick

brown precipitate of a reddiſh colour, reſembling blood, by the nut-gall. Though he did not ſucceed in reducing this oxide, and obtained only brown ſcoria towards the bottom, and a greyiſh blue at the top, yet, as its properties leave no doubt reſpecting its metallic nature, he gave it the name of titanium, an inſignificant term, as he himſelf admits, but, on that account, not calculated to give any falſe notion.

2. Towards the end of the ſame year citizens Miché and Cordier, officers of the mines of the French Republic, diſcovered in the canton of Saint Yriez, in the department of Haute Vienne, a red ſchorl in ſmall broken maſſes, rolled and worn at their ſurface, interſperſed among the ſoil of the fields. It had long been uſed in the manufacture of Sevres to make the brown colour on porcelain; but its uſe was laid aſide on account of the extreme difficulty of obtaining an uniform tint. Citizens Vauquelin and Hecht undertook a very extenſive chemical examination; they verified and confirmed the diſcovery of M. Klaproth; added ſome new facts, particularly a greater degree of preciſion; and they ſucceeded in approaching much nearer than he did to the reduction of this metal, ſo that they have deſcribed ſeveral properties of metallic titanium, of which the Berlin chemiſt made no mention. They have, therefore, ſupplied me with many new details and reſults for this article, which is founded entirely on their experiments as well as thoſe of M. Klaproth.

B. *Phyſical Properties.*

3. The metallic titanium obtained in the manner to be mentioned, exhibits not a true well-fuſed button, but an agglutinated brittle, blackiſh-brown, cavernous maſs, cryſtallized within, hard and brittle, almoſt always wholly or in part of a reddiſh colour, or of a bright ſhining reddiſh-yellow at the ſurface, equally brilliant and red in its internal cavities, frequently covering the ſurface of the crucibles with a lining of the ſame ſhade, changing and aſſuming rain-bow colours or purple when expoſed very hot to the air, volatile and attached to the cover of the crucibles with that red colour by the ſtrong fire employed in its reduction. It is the only metal which ſo much approaches the tinge of copper, though this is mixed with yellow.

C. *Natural Hiſtory.*

4. Titanium is not yet known in the native ſtate, but in the form of oxide. Two ſpecies are diſtinguiſhed. A. The red pure oxide of titanium, named red ſchorl, found in Hungary, Spain, France, and Mount Saint Gothard. The latter was found by M. de Sauſſure, who named it Sagenite on account of its cryſtals having the form of reeds or fillets, ſagena. It is diſ-

ſeminated in long brilliant needles, and included in the rock-cryſtal of Madagaſcar. The form of its molecule is a triangular priſm, with rectangular iſoſceles baſes. It is obtained in the primitive form by dividing the nucleus, in the direction of the diagonals of the baſes of its cryſtals. Theſe are hexahedral priſms, with dihedral ſummits reſembling thoſe of Saint Yriez, or octagonal fluted priſms, like thoſe of Hungary, or ſquare priſms like thoſe found a few years ago near Pont-James les Noyers, between Nantes and Ingrand. Theſe cryſtals are grouped two and two, and croſſed like cryſtals of tin under an angle of 114°. Its colour is red, more or leſs deep, clear and brilliant, and even ſemi-tranſparent on its edges. It eaſily breaks; but its hard fragments are difficult to pulverize. It ſcratches glaſs. Its ſpecific gravity is between 4,180, and 4,246. B. The ſiliceo-calcareous titanium, or the titanite of Klaproth. It is a foſſil compoſed of oxide of titanium, ſilex and lime nearly in equal parts; its ſpecific gravity is 3,510. Before the blow-pipe it only undergoes ſome bliſters at its ſurface. It is found at Paſſau in ſmall right rhomboidal priſms, terminating in dihedral ſummits in a gangue compoſed of feldt-ſpar and quartz.

D. *Assay and Metallurgy.*

5. No docimaſtic aſſay, nor metallurgic works have yet been made on this metallic ſubſtance, which has been diſcovered no longer than three years. Chemiſts may eaſily diſtinguiſh its oxided ore from the different characters it preſents which will be carefully deſcribed in this article. We content ourſelves to obſerve in this place, that Citizen Vauquelin has obtained perceptible ſigns of reduction of the red native oxide, by heating one hundred parts with fifty parts of calcined borax, and fifty parts of charcoal reduced to a paſte with oil, and expoſed in a lined crucible for an hour and half, in a forge-fire raiſed to an hundred and ſixty ſix degrees of Wedgwood's thermometer, beyond which temperature the moſt refractory crucibles of porcelain would melt. He obtained an agglutinated blackiſh maſs of a coppery-red, and brilliant on its ſurface.

6. As metallic titanium is very rare, and has not been obtained, but by Citizen Vauquelin, and in too ſmall a quantity to ſubject it to a ſufficient courſe of experiment; as on the contrary its native oxide has been examined with much care by the two chemiſts who have diſcovered its nature, and drawn up its hiſtory; and laſtly, as the moſt conſtant ſtate in which it has been ſubjected to experiment, is carbo-

nate of titanium, obtained by fuſion of the native oxide of titanium, with ſix parts of carbonate of pot-aſh, during which fuſion the oxide abſorbs oxigen, and carbonic acid which modify its properties, I ſhall in each of the following numbers, when I ſpeak of the action of the various chemical ſubſtances, conſtantly refer their action to the metal, to its native oxide, and to the artificial carbonate. This is the only method of giving a preciſe and methodical notice of what is known reſpecting this new ſubſtance, which is already become ſo intereſting.

E. *Treatment by Fire and Air.*

7. TITANIUM does not melt by the greateſt known heat; it becomes covered with the colours of the rain-bow in the air, and is eaſily oxided; but the augmentation of its weight or the degree of its oxidation has not yet been determined.

8. The red oxide of titanium heated in a crucible becomes brown, and loſes its brilliancy. By the blow-pipe it loſes its tranſparence, and becomes of a milky-grey colour. Upon charcoal it becomes ſtill more opaque, and of a ſlate grey.

9. The artificial carbonate of titanium treated alone in a crucible, loſes 0,25 of its weight, becomes yellow by heat, and reſumes its white colour by cooling. After this heat it is no longer

ſoluble in acids nor effervesces with them; carbonic acid, and a ſmall quantity of oxigen gas is diſengaged. When heated alone by the blow-pipe upon charcoal it becomes of a fine orange-yellow, which diſappears by cooling, and it becomes black at the ſurface which touches the coal. Theſe changes of colour are owing to the loſs of the different proportions of oxigen.

F. *Treatment with Combuſtible Bodies.*

10. No trial has yet been made to combine titanium with combuſtible bodies.

11. The native red oxide, treated with carbon by a ſtrong fire, as we have ſeen, becomes reduced into blackiſh agglutinated grains, covered with a red and very brilliant metallic pellicle.

15. The carbonate of titanium has not been aſſayed, but by carbon mixed with the ſaline fluxes, and by ſtrongly heating thoſe mixtures, a reduced metallic maſs was obtained without fuſion, at leaſt without complete fuſion, the ſurface of which was red and brilliant, and of which the internal cavities were frequently lined with priſmatic cryſtals ſimilar to thoſe of the oxide of manganeſe. When the crucible breaks in this experiment, the matter ſpread about, applies itſelf to the ſurface in a metallic plate of the fineſt purple-red, ſimilar to a leaf of jewellers foil, which circum-

ſtance announces a ſpecies of fuſion in the reduced titanium ſufficiently manifeſt, though it has never yet been obtained in a collected button, for want of veſſels to ſupport the heat, without themſelves becoming fuſed at a temperature above 166 degrees of Wedgwood's thermometer.

13. Neither titanium, nor its native oxide, nor its artificial carbonate, have yet been treated with hidrogen, phoſphorus, ſulphur or any other metallic ſubſtance.

G. *Treatment with Water and the Oxides.*

14. The action of titanium upon water and the metallic oxides has not yet been tried; ſo that we cannot ſtate its rank of attraction for oxigen. There was no motive to examine that of the artificial carbonate of titanium on theſe bodies. It was known that it is not ſoluble in water ſince it was ſeparated from the alkaline carbonate formed by this liquid, and it was more natural to try the native oxide with the metallic oxides, with the intention that by adding the reducing ſubſtances, the titanium might be obtained by the common reduction of the metallic alloy.

15. The memoir of citizens Vauquelin, and Hecht, contains ſeveral experiments of this aſſay of the native oxide of titanium with various metallic oxides, with charcoal, oil, or black flux, and expoſed to a violent heat. That

with the oxide of lead, and a fourth of the former, was found diſſeminated in grains, in a blackiſh brown maſs not fuſed; that of arſenic ſix parts to one of the oxide of titanium afforded a black glaſs, compact and well fuſed without appearance of metallic matter; that of copper in equal parts, afforded only a greeniſh grey ſcoria, under which was found a ſmall button of pure copper; that of ſilver alſo in equal parts afforded a deep green, bliſtered ſcoria, interſperſed with ſmall grains of ſilver, covering a button of the metal in a ſtate of purity, and very ductile. The oxide of iron in equal parts and half of the native oxide of titanium, afforded in ſeveral ſucceſſive aſſays, by the aſſiſtance of a very active flux, indications of alloy between the two metals. This alloy which was well reduced, but did not flow into a button, was of a grey colour, mixed at its ſurface, and in its interior ſhowed brilliant metallic particles of a gold and yellow colour. We ſee therefore, that titanium unites very difficultly, or even not at all with lead, arſenic, copper, and ſilver, but that it appears capable of uniting with iron.

H. *Treatment with the Acids.*

16. The experiments with the acids were much more numerous, and preſented reſults much more intereſting than moſt of the other experiments on titanium. Mr. Klaproth has well deſcribed the inefficacy of theſe ſolvents on the red native oxide of titanium, and their action upon the carbonate of that metal. Citizens Vauquelin and Hecht have ſhown with greater care and accuracy, the effects they produce on the metallic titanium and its artificial carbonate. As the moſt remarkable characters of this new metal conſiſt in thoſe various effects; I ſhall here deſcribe them ſufficiently at length to give an accurate knowledge of the ſame.

17. Titanium (numbers 3 and 5) treated with concentrated and boiled ſulphuric acid, afforded ſulphureous acid gas, and was changed into a white oxide, part of which remained diſſolved in the acid. This ſolution preſented all the characters of the ſolution of carbonate of titanium in the ſame acid which will ſpeedily be mentioned; there is, conſequently, no doubt, as Citizens Vauquelin and Hecht remarked, that the red metallic ſubſtance, obtained by the reduction of the native oxide, is the metal titanium.

18. The nitric acid long boiled upon this metal, did not exhibit any remarkable effect; nevertheleſs, the brilliant points of this metal were changed into a white ſubſtance, which ſhows, that they were oxided at their ſurface.

19. The muriatic acid diluted with water, afforded much hidrogen gas with titanium in blue ſcoria. [We muſt here obſerve, that the portion of red titanium which was only a ſuperficial coating, was too ſmall in quantity to be ſubmitted in this ſtate to the action of all the acids]; a conſiderable quantity of white flakes was formed in the liquor. The nitro-muriatic acid converted it ſpeedily into a white powder, which was diſperſed through the fluid, and the ſurface of the metal was alſo at firſt covered with a ſimilar white pellicle. We ſhall ſoon ſee, that this ſuſpenſion of oxided titanium by the decompoſition of water in the muriatic acid, is ſimilar to what happens between the carbonate of this metal and the ſame acid.

20. Mr. Klaproth treated the native red oxide of titanium from Hungary, with the ſulphuric, nitric, muriatic, and nitro-muriatic acid, digeſted with heat for a conſiderable time upon this oxide in powder. There was no perceptible action, and the oxide remained without alteration. Citizens Vauquelin and Hecht, by treating the ſame red oxide of titanium from St. Yriez, obſerved, that the ſulphuric acid concentrated and boiled, detached merely a few perceptible indications of iron, without changing

the oxide; that the nitric acid was equally ineffectual, and the muriatic acid produced only a ſlight modification in the colour which became rather grey.

21. This is not the caſe with the carbonate of titanium obtained by fuſion of its native oxide with carbonate of pot-aſh in the experiments of Mr. Klaproth, as well as in the more multiplied experiments of Citizens Vauquelin and Hecht. All the acids act in a ſingular manner upon this carbonate, and it is evident, that this is owing, as theſe laſt chemiſts obſerved, to the abſorption of oxigen and carbonic acid occaſioned by the fuſion with the carbonate of pot-aſh. It is true, that it is a remarkable circumſtance to find a native oxide not ſaturated with oxigen, which does not take that principle by the action of the nitric acid, but becomes charged with it by fuſion with the carbonate of pot-aſh. We ſhould be tempted to think with Mr. Klaproth, that it rather loſt a portion of oxigen in this fuſion which it naturally contained, and which might render the native oxide inſoluble in acids, if the experiments of Citizens Vauquelin and Hecht did not compel us to draw a contrary inference from the facts they have ſo carefully obſerved.

22. Mr. Klaproth aſſerts, that the carbonate of titanium, which he calls white earth of this metal, obtained by the action of the carbonate of pot-aſh upon the red ſchorl, is totally ſoluble by heat in the ſulphuric acid diluted with

water, and that this clear ſolution, when evaporated, becomes converted into a white gelatinous and opaque ſubſtance. In the experiments of Citizens Vauquelin and Hecht, the carbonate of titanium, which was boiled with ſulphuric acid at 40°, produced an effervefcence and gave a milky appearance to the fluid; many white flakes ſimilar to curds in milk were formed; a ſtronger heat completed the ſolution and afforded a tranſparent liquid; this ſolution did not afford cryſtals.

23. According to Mr. Klaproth, the nitric acid formed with the carbonate of titanium a tranſparent ſolution, which becomes of an oily appearance in the air, and affords tranſparent cryſtals in elongated rhombs, as if truncated in two oppoſite points, ſo as to repreſent hexagonal plates. Citizens Vauquelin and Hecht obſerved ſomewhat more in this operation. The carbonate of titanium, according to them, effervefces ſtrongly with concentrated nitric acid: when the mixture is heated, the nitrous acid is diſengaged; the fluid remains continually milky; ſugar added to the mixture precipitates an oxide which is whiter than the carbonate was. If diluted nitric acid be uſed, the oxide of titanium is diſſolved, but the ſolution becomes turbid by heat. Caloric, therefore, oppoſes the combination of this oxide with the nitric acid, by oxiding the metal ſtill more, and by that means renders it inſoluble in the acid.

24. In the experiments of Mr. Klaproth, the carbonate of titanium was ſoluble in the muriatic acid; and this ſolution formed a yellowiſh and tranſparent jelly, in which he obſerved many tranſparent cubical cryſtals. The experiments of Citizens Vauquelin and Hecht preſent ſtill more information reſpecting this ſingular compound. The carbonate of titanium was diſſolved with efferveſcence in the concentrated muriatic acid, and aſſumed a deep yellow colour while it was diſſolving, without the aſſiſtance of heat; the ſolution was yellow, though ſaturated, it was conſtantly acid; when heated, it became reduced into a flocculent magma, which was not re-diſſolved by the addition either of water or of more muriatic acid. A ſimilar ſolution, which was not heated, remained tranſparent; at 60° of heat it afterwards became a tranſparent yellow, of a very ſtyptic acid taſte: by cooling of this jelly it depoſited many ſmall cryſtals, which effloreſced in the air. When this ſolution was boiled, oxgenated muriatic acid eſcaped; the oxide precipitated by heat was no longer ſoluble in the muriatic acid; and the chemiſts before cited, proved that this fact is owing to a diſoxidation, becauſe it becomes capable of being again diſſolved without heat, after it has been long boiled with the nitric acid. The contrary, therefore, takes place, in this inſtance, to what happens with the nitric ſolution; the oxide of titanium requires to be ſtrongly oxided in order

to unite with the muriatic acid; and in this ſtate it is only ſoluble at a cold temperature, becauſe the acid, when heated, ſeizes a portion of its oxigen, and renders it inſoluble. The oxide of titanium, when too highly oxigenated, cannot be diſſolved in nitric acid; and when this laſt ſolution is ſtrongly heated, the titanium, by decompoſing the nitric acid, and ſeizing oxigen from it during the diſengagement of nitrous gas, becomes ſeparated from the acid, and renders the ſolution of a milky whiteneſs. When therefore it is ſupercharged with oxigen, it is ſoluble without heat in the muriatic acid, and becomes diſoxided by the application of heat. The oxide of titanium, ſeparated from the muriatic acid by the action of the blow-pipe, aſſumes a beautiful lemon-yellow colour.

25. The ſolutions of the oxide of titanium in the acids are precipitated by the carbonate of pot-aſh, and by ammonia, in white flakes, by the pruſſiate of pot-aſh, of a graſs green, mixed with brown, by nut-gall of a reddiſh-brown, reſembling the colour of blood, by the arſenic and phoſphoric acid in white powder. The muriate of titanium in which tin is plunged, becomes firſt of a pale red colour, and afterwards of a ruby-red; zinc changes its yellow colour to a violet, which paſſes to that of indigo. Heat deſtroys theſe fine colours. The muriatic ſolution of titanium is not rendered turbid by water, charged with ſulphurated hidrogen. The

ſulphuret of ammonia colours it of a dirty green, and forms a precipitate of a bluiſh green; the white carbonate of titanium, or the white oxide ſeparated from the acids, becomes alſo coloured of a greeniſh blue, when the ſulphuret of ammonia is poured in. All theſe facts, curious for the beauty of the ſpectacle, and the variety of the phenomena, were diſcovered by Mr. Klaproth, and verified by Citizens Vauquelin and Hecht. They have added the following fact; that the light green precipitate, formed in the muriate of titanium by the pruſſiate of pot-aſh, paſſes through brilliant ſhades of purple, blue and white, where it ſtops, when it is decompoſed in the midſt of the fluid in which it was obtained by the addition of alkalis.

H. *Treatment with the Alkaline Baſes and the Salts.*

26. The action of the alkalis and the ſalts upon titanium are not known; it appears to be capable of oxidation by the nitrates and the ſuper-oxigenated muriates.

27. The native red oxide of titanium, heated with four parts of pure pot-aſh, melts and becomes divided at the ſame time that it aſſumes a white colour; the diviſion which the alkali produces in it renders it ſoluble in the acids, though it is not ſo in its natural ſtate of denſity.

28. When heated by the blow-pipe with phoſphate of ſoda and ammonia, this native oxide melts with ebullition, and affords a black glo-

bule when entire, but of which the fragments are violet. With borax, it affords a yellow green compound inclining to brown. Similar ſhades, but brighter, clearer, and more tranſparent, are obtained by treating the carbonate of titanium with the ſame ſalts; which appears to depend on being then deprived of the ſmall portion of iron which it contains in its native ſtate.

29. We have already obſerved, that when in a crucible, heated with ſix parts of carbonate of pot-aſh, the native red oxide of titanium melts, becomes greeniſh, and that by diluting this maſs in water, this fluid diſſolves the cauſtic alkali, and leaves the carbonate of titanium infinitely more divided than it was in its native ſtate. This reſult proves, that the oxide of titanium when heated, has a ſtronger attraction for carbonic acid than pot-aſh has, from which it ſeizes it; and as an hundred parts of the oxide weighed 157, after this operation, though the carbonate of titanium loſes only 0,25, of carbonic acid by calcination, it is evident, that the oxide of titanium beſides the carbonic acid, has alſo abſorbed near 0,11 of oxigen during its treatment with the alkaline carbonate. This accurate experiment induced Citizens Vauquelin and Hecht to ſuppoſe contrary to the opinion of Mr. Klaproth, that by the effect of its alkaline fuſion, the native oxide of titanium becomes more burned than before, and in conſequence of that proceſs, becomes more ſoluble in the muria-

tic acid. We muſt, nevertheleſs add, that its ſtate of diviſion alſo contributes to render it ſoluble, ſince, by heating it, and merely depriving it of carbonic acid, the ſimple concentration, or condenſing of its particles, is ſufficient to deprive it of its ſolubility.

K. *Uſes.*

30. It is ſcarcely to be preſumed, that titanium can become uſeful in its metallic form ſo long as no means ſhall be diſcovered of completely reducing and fuſing it; and this laſt point appears very difficult to be obtained, becauſe this metal appears to be no leſs, but probably even more infuſible than platina. In its ſtate of oxide, particularly when purified and attenuated by fuſion with the alkalis, it may be uſed with much advantage to colour enamels pottery and porcelain. It is alſo uſed to afford a fine ſtrong yellow on the porcelain of Berlin; and though it has been rejected as a brown at the manufacture of Sevres, where it was never found to afford a uniform tinge, this no doubt ariſes from the operators having taken the native oxide in which a portion of iron may cauſe the vitrification and ſhade to vary; but when purified and more oxided, it may be uſed to compoſe a brilliant yellow colour as is found to be the caſe at Berlin. Beſides which, when its ſtate of oxidation is varied and it is mixed with other oxides, we may expect to obtain violet,

orange, brown, and green colours of a variety of tints.

ARTICLE VII.

Concerning Uranite.

A. *Hiſtory.*

1. IN the month of October 1789, a letter of Mr. Crell, inſerted in the Journal of Phyſic, informed the French chemiſts, that Mr. Klaproth, of Berlin, had diſcovered in the pech-blende and green glimmer of Saxony, a new ſemi-metal which he named uranite. It was announced, that this metal was more difficult to reduce than manganeſe, that its external colour was grey, and that internally it inclined to a light brown; that its ſpecific gravity was 6,440, its brilliancy ſcarcely conſiderable, and its hardneſs moderate; that it could be ſcraped and filed; that its oxide afforded by the aſſiſtance of a flux, a deep orange colour for porcelain.

2. In April 1790, the diſſertation of Mr. Klaproth on this new metal was inſerted entire in the ſame journal. The following is the order in which the author has arranged his work; it is divided into twenty-nine paragraphs.

The firſt paragraph exhibits the opinion of authors reſpecting the pech-blende of George

Wagsfort, John at Georgenſtadt. Mr. Werner, ranked it among the ore of iron; and ſuſpected that it conſiſted of a combination of tungſtic acid with metal.

In the ſecond paragraph, the ore of the new metal is carefully deſcribed and diſtinguiſhed into two varieties: the firſt of a ſteel grey, having the ſpecific gravity 7,500, mixed with particles of ſulphuret of lead; the ſecond blacker, more brilliant, leſs hard, accompanied with yellowiſh earth, mixed with ſquare green plates of glimmer, or green mica.

In the third, he examines the pech-blende by the blow-pipe without addition, and with ſaline flux.

In the fourth, he treats it in the retort and by roaſting; he obtained ſulphureous acid and ſulphur; he obſerves, that when the veſſel is open, it increaſes in weight after having loſt its ſulphur.

In the fifth, he examines it by the ſulphuric and by the nitric acid, which diſſolves it better and ſeparates the ſulphur.

In the ſixth, he treats it by the muriatic and the nitro-muriatic, which ſeparates the ſulphur, develops the lead, and affords cryſtals of ſalt formed by the new metal.

In the ſeventh, he deſcribes ſome properties of its nitric and nitro-muriatic ſolutions.

In the eighth, he ſpeaks of its precipitations by the pruſſiate, and by the alkalis, which are conſtantly yellow.

In the ninth, he announces thoſe precipitates which form the carbonates.

In the tenth, he ſhows the ſolubility of the new metal precipitated from its ſolutions by the acids; it is greater than that of the ores.

In the eleventh, we find that pech-blende is inſoluble in the alkalis.

In the twelfth, the oxide by precipitation is examined by the blow-pipe, and by the fluxes; the author ſpeaks of unſucceſsful attempts to reduce it by means of the fluxes.

In the thirteenth, and fourteenth, he deſcribes the ſucceſſive proceſſes by which he ſucceeded beſt in this reduction.

In the fifteenth, renouncing the expectation of aſcertaining the properties of this new metal in the metallic ſtate, he examines the colour which its oxide may be capable of giving to glaſs and to porcelain.

In the ſixteenth, concluding from all the experiments before deſcribed, that pech-blende contains a new metal, he names it uranium, aſſuming after the manner of the ancient philoſophers, the name of the new planet diſcovered by Herſchel, Uranus.

In the ſeventeenth, he examines the native metallic oxide of uranite in a pure ſtate, which is found in the mine of George Wagsfort, and is the yellowiſh earth mentioned in his ſecond paragraph.

In the eighteenth and nineteenth paragraphs, he refers to the ores of uranite, the glimmer, or green mica, which is found at the place laſt mentioned, and at Eibenſtock, which Bergmann ſuppoſed to be muriate of copper, and was called calcholite by ſome mineralogiſts, but is merely the oxide of uranite coloured by the oxide of copper; ſome ſpecimens contain no copper, and have the yellow colour of wax. At the end of his diſſertation, he concludes that we muſt place uranite as a new genus among the brittle metals of difficult fuſion. He diſtinguiſhes three ſpecies, 1. The ſulphureous uranite, of which there are two varieties, the firſt of a deep grey mixed with ſulphuret of lead; the other black, reſembling pit coal. 2. The uranite of a yellow, and, as it were, earthy oxide. 3. The uranite cryſtallized in ſquare plates, of which there is one variety pure and yellow, and the ſecond tinged green by the oxide of copper.

B. *Phyſical Properties.*

3. I HAVE given this hiſtorical notice at ſome length, becauſe I was deſirous of ſhowing the difficulties Mr. Klaproth found in reducing his new metal, and the impoſſibility of deſcribing its properties in the preſent ſtate of our knowledge, at the ſame time that the neceſſity of examining the properties of its oxide becomes more evident. I ſhall obſerve, that the word uranium, adopted by the chemiſt of Berlin, and hitherto tranſlated into French by the term

uranite, appears to me as well as to Citizen Guyton, much better adapted to our language by converting it into the term urane, which I ſhall hereafter uſe.

4. If we condenſe the notions we poſſeſs reſpecting the phyſical properties of uranite, of which the ores have hitherto been very ſcarce, and which no French chemiſt has yet obtained metallic, for want of the ſubject; we ſhall find, that this metal has not been obtained except in a maſs ſlightly coherent, conſiſting of ſmall agglutinated globules, like many of the preceding metals. Its colour of a deep grey, exhibits a pale brown when ſcratched. It has little brilliancy, on account of the poroſity of this agglutinated maſs. It may be ſcraped with a knife or worn by the file. It is as it were, intractable and infuſible.

C. *Natural Hiſtory.*

5. Three ſpecies of the ores of uranite are at preſent diſtinguiſhed.

A. The firſt is the ſulphuret of uranite; it is black, of various depths of ſhade, ſhining in its fracture, and ſometimes lamellated; this is the pech-blende of ſeveral mineralogiſts; its ſpecific gravity is between 6,37, and 6,53. Mr. Klaproth gives its ſpecific gravity 7,50. The ſulphuret of zinc with which it has been confounded, weighs only 4,16. It contains, as it ſhould appear, little ſulphur; it often affords iron, and ſulphuret of lead. The uranite exiſts in the metallic ſtate. Mr. Klaproth has diſtinguiſhed two varieties.

B. The ſecond is the native oxide of uranite. It always exiſts in the form of yellow powder at the ſurface of the ſulphuret; there are brown or blackiſh varieties, on account of the oxide of iron which is mixed with it; ſome mineralogiſts have given it the name of uranochre in this ſtate. Its ſpecific gravity is 3,24. When it is of a pure, equal, and bright yellow, it may be uſed in chemical experiments as a pure oxide of uranite.

C. The third ore of this metal is the native carbonate of uranite. There are two very diſtinct varieties; one of a pale green, and ſometimes even of a ſilvery white, according to Mr. Klaproth: this contains little or no oxide of copper; it is very ſcarce: the other is of a deep very brilliant green; it is the green mica, glimmer, chalcholite, or braſs ſtone of authors. It has ſometimes been taken for mica, ſometimes for ſulphate of barites, and ſometimes for a muriate of copper. Mr. Klaproth has pointed it out as an oxide of uranite mixed with the oxide of copper. It has ſince been found to contain carbonic acid. It is cryſtallized in ſmall ſquare plates, with double chamfers at their edges, that is to ſay, in naſcent octahedrons, and not truncated, as ſo many mineralogiſts have falſely aſſerted. Sometimes, though very ſeldom, it is found in complete octahedrons, Mr. Klaproth mentions it as exiſting in the cubic form.

The native uranite has not been found either in alloys, or with its oxide combined with any other acids except the carbonic.

D. *Aſsay and Metallurgy.*

6. THERE are no regular aſſays of the ores of uranite, and ſtill leſs, of metallurgic works on this metallic ſubſtance, which has only been found in ſmall quantities in Saxony. Mr. Klaproth having to a certain point ſucceeded in extracting the metal, we may conſider it, and I ſhall here deſcribe his proceſs as a docimaſtic method. The yellow oxide of uranite precipitated from its ſolutions by an alkali having been mixed with honey and oil to form a paſte, he burned the mixture in a teſt: a black powder remained, which had loſt rather more than one fourth of its weight; this was put into a lined and well-cloſed crucible, and expoſed to heat in a porcelain furnace in contact with another crucible, containing as terms of compariſon, oxide of manganeſe treated in the ſame manner. After the operation of the heat, the latter was well reduced; but the oxide of uranite was beneath the powder of charcoal in a coherent maſs, friable between the fingers in a black ſhining powder, which decompoſed the nitric acid with effervеſcence, in the form of red vapour: whence, Mr. Klaproth concludes that the oxide

of uranite was reduced, but without fuſion, becauſe it is ſtill leſs fuſible than mangaueſe. The ſame uranite in black powder was placed in a lined teſt covered with calcined borax, and then well-cloſed. He expoſed this veſſel to the hotteſt part of the porcelain furnace: this treatment afforded him the metallic maſs, conſiſting of very ſmall agglutinated globules.

7. With regard to the aſſays, the following details, which belong rather to the oxide than to the metal, will explain the proceſſes.

E. *Oxidability by the Air.*

8. URANITE ignited in the fire with expoſure to air, or by the flame of the blow-pipe, underwent no change, ſo that it appears to be difficult of combuſtion and oxidation. In an aſſay with phoſphate of ſoda and ammonia, the ſurface of the globule became graſs green.

9. The yellow oxide of uranite does not melt; it becomes of a browniſh grey when long heated in contact with the air. It is not known whether it loſes or gains oxigen by this proceſs.

F. *Treatment with Combuſtibles.*

10. WE have ſeen that this oxide is reduced by charcoal with heat. No experiment has yet been made to unite uranite with ſulphur, though it is very probable that its ore might be artificially formed in this manner. Neither is its combina-

tion with phoſphorus known. It appears, that uranite combines readily with it ſince Mr. Richter, by treating the oxide of uranite with bullocks blood and a forge-heat, obtained a button ſimilar to cobalt in its colour, very ſhort and brittle which as Mr. Gren thinks, was manifeſtly phoſphorated, and owes its great fuſibility to the phoſphorus which it contains.

11. We have no knowledge reſpecting the alloys of which titanium may be ſuſceptible, and we find no experiment relating to this object among thoſe of Mr. Klaproth.

G. *Action upon Water and the Oxides.*

12. The ſame obſervation applies to its action upon water and the metallic oxides; theſe have not been appreciated, neither can we ſay any thing reſpecting its comparative attraction for oxigen.

H. *Treatment with the Acids.*

13. Except the decompoſition of the nitric acid by uranite, in the black brilliant powder which I have already mentioned in the article of aſſay, there is no fact yet known concerning the mutual action of this metal and the acids; but the action of theſe burned bodies upon the oxide of uranite has been better appreciated; the principal part of the labours of Mr. Klaproth's inquiry conſiſts in this, and the moſt remarkable

characters of the metal here treated are thus aſcertained.

14. The yellow oxide of uranite is readily diſſolved in the ſulphuric acid diluted with water, and affords by evaporation, a ſalt of a lemon colour, in ſmall priſms united in bundles. This ſulphate of uranite differs in its colour, its form, and its other properties from all the known metallic ſalts.

15. The nitric acid alſo diſſolves the oxide of uranite with much facility; the ſolution by gentle evaporation affords large cryſtals in hexagonal tables of a light or yellowiſh green, which are very regular. This nitrate of uranite is one of the moſt beautiful metallic ſalts we know of.

16. The muriatic acid alſo diſſolves the oxide of uranite, and, according to Mr. Richter, affords ſmall yellowiſh cryſtals of muriate of uranite, which are deliqueſcent.

17. The fluoric acid combines with this oxide, diſſolves it, and forms a cryſtallized ſalt unchangeable in the air.

18. The phoſphoric acid united to the oxide of uranite, forms yellowiſh white flakes ſlightly ſoluble in water.

19. Arſenical acid unites with this oxide by decompoſing the nitrate of uranite by the alkaline arſeniates. A precipitate of whitiſh yellow is thus obtained.

20. The molybdate of uranite is alſo obtained according to Mr. Richter, in powder of a yel-

low white, with browniſh reflections, by pouring the ſolution of molybdate of pot-aſh into the nitrate of this metal.

21. The acid ſolutions of the oxide of uranite are precipitated by the alkaline ſulphurets in a browniſh yellow, and their ſurface is at the ſame time covered with a grey metallic pellicle: the infuſion of nut-gall thrown into one of theſe ſolutions, of which the exceſs of acid has been abſorbed by an alkali, forms a chocolate-brown precipitate. Zinc, iron, and tin plunged in the ſolution ſeparate nothing, and produce no modification in its colour, either with or without heat. The fixed alkalis precipitate from theſe ſolutions a lemon-yellow coloured oxide of uranite. Ammonia affords a yellower precipitate; the alkaline carbonates ſeparate a carbonate of uranite of a white yellow, which is re-diſſolved in an exceſs of the precipitants.

I. *Treatment with the Baſes and the Salts.*

22. The fixed alkalis do not diſſolve uranite nor its oxide in the humid way, even at the boiling heat; the oxide merely aſſumes a deep brown colour. The alkaline carbonates, on the contrary, diſſolve it eaſily, and the acids precipitate from theſe ſolutions an oxide of a clear yellow colour.

23. The oxide of uranite combines with the ſaline fluxes, and communicates different colours to them according to their nature, proportion,

and ſtate. Among others, the following colourations are known.

A. Eight parts of prepared ſilex, four parts of pot-aſh, and half a part of the oxide of uranite afford, by fuſion, a glaſs of a bright tranſparent brown colour. Soda ſubſtituted to pot-aſh in this compoſition, produces a glaſs of a grey black.

B. One part of the oxide of uranite, eight parts of ſilex, and the ſame quantity of calcined borax, afford a glaſs ſimilar to the ſmoky topaz.

C. The ſame proportion of ſilex, oxide of uranite, and vitreous phoſphoric acid afford an apple-green enamel ſimilar to the praſe or chryſo-praſe.

D. Half a part of this oxide, and eight parts of the vitreous phoſphoric acid fuſed together, afford a tranſparent glaſs of the colour of the emerald.

K. *Uses.*

24. Uranite has not yet been employed on account of its ſcarcity, and the few experiments to which it has yet been ſubjected. It is evident from what has been here ſtated, and from the obſervation of the orange colour which its oxide gives to porcelain, that it may be uſed for the fabrication of coloured glaſs, enamel, pottery, and porcelain.

ARTICLE VIII.

Concerning Cobalt.

A. *Hiſtory.*

1. COBALT, alſo denominated cobalt occaſionally, was unknown to the ancients, who made their blue enamels with certain preparations of iron according to Gmelin, was, as it appears, employed and known for vitrification of a blue colour about the end of the ſixteenth century. Preuſsler in 1571, Jenitz, and Harren in 1575, were the firſt who eſtabliſhed manufactories of glaſs of cobalt in Bohemia and in Saxony. It was about the year 1732, that Brandt, a Swediſh chemiſt, extracted with ſome care cobalt from its ores, and announced it to be a peculiar metal, different from all other metals. Lehman, in his Cadmiology publiſhed in 1761, ſtudied its hiſtory and properties with much depth and detail from the time in which he wrote; but his attention was more occupied with its ore and vitreous blue than with the metal itſelf. Bergmann has added much to what was known before his time; he gave greater accuracy to the works of his predeceſſors in the examination of this metal. He deſcribed its reſemblances and differences compared with

nickel, manganeſe and iron, to which cobalt conſiderably approaches, and ſhowed that it is very difficult to purify. Scarcely any thing has been done with regard to it ſince his time. Moſt of the ſyſtematical authors have treated ſlightly of it. Macquer in his dictionary of chemiſtry, has given only half a page of ſome inaccurate general notions reſpecting this metal. For the moſt part it has been too much neglected in chemical works. Some chemiſts ſtill conſider it as an alloy. We ſhall ſee how little foundation there is for this opinion.

B. *Phyſical Properties.*

2. COBALT extracted and purified by the proceſſes hereafter to be deſcribed, is of a grey colour, inclining to roſe or red, of a very fine cloſe granulated texture. Its fracture is rough, and exhibits no indication of plates. It is, eaſily reduced into very fine powder, which is grey and of little brilliancy. It has always been ranked among ſemi-metals on account of its brittleneſs. Its ſpecific gravity is, according to Bergmann 7,700, and according to Citizen Guyton 7,811. This laſt chemiſt gives it the ſixth rank among the metals for its hardneſs. He places it, for its property, near tin, after zinc, and gold, and before lead and antimony. It has no determinate taſte nor ſmell, nevertheleſs, when rubbed for a long time between the fingers

it ſtains them, and leaves a perceptible impreſſion in the mouth and noſe.

3. The conducting, electric, and dilatable properties of cobalt have not been comparatively examined with regard to the other metals. Some authors have pretended, that it is magnetic of itſelf; but it is probable, that this magnetiſm is owing to a ſmall quantity of iron, which remains almoſt always alloyed with cobalt, and from which it is very difficult to clear it.

4. Cobalt is one of the moſt difficult metals to fuſe. Nevertheleſs, it does not approach the infuſibility of titanite, uranite, chrome, nor even platina and manganeſe. Many authors have ranked it with iron on account of this property, and Citizen Guyton, in fact, eſtimates its fuſibility at 130 degrees of the pyrometer of Wedgwood, like that of iron. Mr. Kirwan compares its fuſibility to that of copper; but it is much leſs. It ignites long before it melts. It flows difficultly, or it has only a thick fuſion in our furnaces. When ſuffered to cool ſlowly, and by decanting the liquid portion from the midſt of its maſs already fixed on the edges, we find the cavity lined with priſmatic cryſtals, or cryſtals in needles amaſſed together, which the lens ſhows to be placed irregularly one upon the other, like the broken priſms of baſaltes. This cryſtallization ſucceeds very well, by inclining the crucible, which contains the melted metal, at the moment in which its ſurface fixes; in pro-

portion as the liquid portion flows off, the other part which adheres to the congealed maſs preſents theſe accumulated priſms.

C. *Natural Hiſtory.*

5. We are as yet acquainted, with preciſion, with only four ſtates of cobalt in nature, or four ores of this metal; for it has never been found pure or native in the earth. In the firſt, it is alloyed with arſenic both in the metallic ſtate; in the ſecond, the metal is combined with ſulphur and arſenic at the ſame time; the third is an oxide of cobalt, and the fourth an arſeniate of the ſame metal.

6. The firſt ſpecies, arſeniated cobalt, commonly called arſenical ore of cobalt, is of a grey, or more or leſs brilliant white colour, ſometimes mixed with red, of a cloſe grain, ſimilar to that of cobalt, without perceptible laminæ in its fracture, and of the ſpecific gravity 7,72; whiter and more brilliant when cryſtallized than in its irregular pieces, in which laſt form it imitates the beautiful white of ſilver. Its varied forms are the ſmooth cube, the octahedron, the cubo-octahedron, or cube with eight angular facets. The fragments of this arſeniated cobalt, plunged in the flame of a candle, emit a vapour, having the ſmell of garlic: by the blow pipe, this vapour is more abundant, and the heated maſs becomes attractable by the magnet; which

ſeems to ſhow that this ore contains a ſmall quantity of iron.

7. The ſecond ſpecies denominated grey cobalt by Citizen Haüy, becauſe its nature is not yet well determined, but which ſeveral mineralogiſts have called the arſenico-ſulphureous ore of cobalt, or cobalt with iron and arſenic, mineralized with ſulphur, differs from the preceding by its grey colour of tin, and a ſlightly yellowiſh colour internally; by its leſs ſpecific gravity, which lies between 6,33 and 6,45; by its very laminated ſtructure; by the abſence of the vapour, and ſmell of garlic, when preſented to the flame of a candle; by both theſe properties by the blow-pipe, though leſs ſtrong than in the arſeniated cobalt; and by its not becoming attractable by the magnet, like the former when it has been heated. This ore, of which the form of the nucleus is the cube, affects in its ſecondary forms the octahedral, dodecahedral, with pentagonal faces, the icoſahedral, the cubo-dodecahedral ſolid, and the cubo-icoſahedral ſolid, like the ſulphuret of iron, which is often found mixed with it. The cubo-dodecahedral cryſtals which are frequently found in this cobalt, have, like thoſe of the ſulphuret of iron, their facets rectangular, charged with longitudinal ſtreaks in different directions upon the three faces not parallel to each other. This ſo remarkable analogy in the form, gives reaſon to believe, that this ore is a ſulphuret of iron containing cobalt. Citizen Haüy obſerves, nevertheleſs, that there are varieties of grey

cobalt which are not found among the ſulphurets of iron, and among others, that which he names partial grey cobalt, becauſe the cuneiform, or decahedron or octahedron, with two rectangular marginal facets on the extreme edges, reſult from laws of diminution, which, inſtead of being repeated on all the parts of the nucleus ſimilarly ſituated, act only with reſpect to ſome of them, and conſequently, have only a partial exiſtence. This grey cobalt has not yet been accurately analyzed, though it is the ſpecies of ore moſt frequently employed in ſome of the arts, and particularly in the manufactures of porcelain.

8. The third ſpecies is the black oxide of cobalt, named by mineralogiſts black cobalt in effloreſcence, or vitreous ore of cobalt; it exiſts in black friable maſſes ſimilar to ſcoria, or in a black efflorefcence, ſoiling the fingers and often mixed with oxide of iron. It is a pure oxide of cobalt.

9. The fourth ſpecies is the arſeniate of cobalt, named by mineralogiſts, flowers of cobalt, or cobalt in efflorefcence. Its colour is lilac-grey or of peach-flower, or vine lees; ſometimes in ſimple efflorefcence, ſometimes in roſets formed of needles of a deep colour which they preſerve even after pulverization, and ſometimes with four-ſided priſms terminating in ſummits of two faces. When heated upon charcoal, it emits a ſtrong odour of garlic, and then loſes its colour and becomes black. It is frequently diſſe-

minated in powder upon oxides of iron, of copper, upon the mixed ores containing native ſilver, and in this ſituation, mineralogiſts have improperly called it the gooſe-dung ſilver ore, on account of the very varied ſhades which the different oxides mixed in this foſſil preſent.

10. Moſt mineralogiſts have enlarged the catalogue of ores of cobalt greatly beyond what is here preſented. They have deſcribed a ſulphureous ore of cobalt, or pure ſulphuret of cobalt diſcovered in 1742, by Brandt, at Baſtnaes near Riddarhytan, in Sweden; but Cronſtedt, Wallerius, Romé de Liſle, have conſidered it as ſulphurated iron containing cobalt, or ſulphurated cobalt containing iron, whereas Bergmann thinks that the cobalt and iron are merely contaminated with ſulphuric acid, and admits, on the other hand of a ſulphurated cobalt containing very little ſulphur. There is, conſequently, much uncertainty reſpecting this ore, which is not known to the French mineralogiſts, and is deſcribed with much variation, and even oppoſition by different authors. Baron de Born who makes this reproach, indicates a ſulphurated oxide of cobalt which is alſo rejected by other mineralogiſts.

11. The cobalt tricoté of the mineralogiſts is likewiſe not a true ore of this metal; it is merely ſilver in dendrites, altered by its union with arſenic and cobalt. The name of teſtaceous cobalt has alſo been improperly given to the native ſcaly arſenic, and I have remarked in the hiſ-

tory of this laſt metal, that this very dangerous error is frequently committed in the ſhops of druggiſts.

12. The four ores of cobalt, diſtinguiſhed and deſcribed before, are found at Baſtnaes, and in other parts of Sweden, and in Hungary, in Auſtria, in Bohemia, in France, in the Pyrenees, in Voſges, and in a great number of other places.

D. *Aſſay and Metallurgy.*

13. IN order to aſſay the ore of cobalt in the dry way, and to determine how much metal it will afford, it is pounded, waſhed, and roaſted in an open teſt, continually ſtirring it till it no longer affords any vapour of arſenic. The oxide of cobalt of this roaſting, which has the form of black powder, is mixed with three times its weight of black flux, and a ſmall quantity of decrepitated muriate of ſoda; this mixture is melted in a lined crucible, covered and expoſed to the heat of a forge; when the fuſion is completed, and the matter perfectly liquid, the crucible is ſlightly agitated and gently ſtruck with an iron rod, in order to collect together the metallic globules, and cauſe them to precipitate. When the cold crucible is afterwards broken, it is frequently ſeen, that two metallic buttons have been precipitated beneath a well-fuſed vitreous ſcoria; the cobalt occupies the upper place, and biſmuth the lower, becauſe it is the heavier: a blow of the hammer inſtantly ſepa-

rates them. Theſe two metals are obtained in the aſſay, becauſe the ores of cobalt are very frequently mixed with thoſe of biſmuth; but they are not obtained when the ore of cobalt is carefully ſelected, and accurately ſeparated from that of biſmuth. We muſt obſerve, that the cobalt thus obtained contains almoſt always arſenic, nickel, and iron; and we ſhall hereafter ſhow how it may be purified. Nevertheleſs, by uſing well-cryſtallized grey cobalt, we may procure the metal as pure as poſſible, by the ſimple proceſs of reduction here deſcribed; the richeſt ores afford from 60 to 80 per cent. and the pooreſt only 25.

14. Bergmann and Kirwan have deſcribed methods for the humid aſſay of the cobalt ores. They conſiſt in treating them by the nitric acid, which oxides and diſſolves the cobalt and the iron; theſe oxides are precipitated by the carbonate of ſoda, then waſhed and ſeparated by the nitric acid, which diſſolves that of cobalt, without touching the iron. The ores of cobalt, which contain the oxide of the metal, are eaſily attacked by the muriatic acid. Thoſe which are difficult to diſſolve in the firſt mentioned acids, are ſoluble in the nitro-muriatic. Bergmann conſidered moſt of the ores of cobalt as containing this metal in the native ſtate; and he did not admit the ſtate of oxide, excepting in the vitreous ore and the arſeniate of cobalt.

15. Scheffer adviſes to aſcertain and determine the colouring property of the ores of

cobalt, becauſe it is by this property that they are uſeful to the arts, and for this purpoſe he directs fuſion with three parts of common pot-aſh, and five parts of glaſs in powder; this proceſs is far from being as accurate and uſeful as it ſeems to be. It is neceſſary to ſeparate the ſulphur and arſenic by previous roaſting, and to oxide the cobalt in order to render it more ſuſceptible of combination with glaſs: this method even then has little real advantage, becauſe it does not afford an accurate term of compariſon between the different matters, vitrified and coloured blue by this oxide. It can only be conſidered as an approximation of ſome uſe to direct works on a large ſcale.

16. The ores of cobalt are wrought in the large way, but not for the purpoſe of extracting metal. After pounding and waſhing the ore, whatever may be its nature, it is roaſted in a furnace, which terminates in a long horizontal gallery, conſtructed of boards, and ſerving for the uſe of a chimney; during the roaſting, the arſenic is always contained in the ore of cobalt (for we muſt remark, that it almoſt conſtantly happens that two or three of the four ſpecies of ores above deſcribed, are found together in the veins or maſſes of cobalt mineral extracted out of the earth); this arſenic oxides and ſublimes in the gallery, where it is depoſited, one ſtratum after another, and from whence it is detached from time to time under the name of white arſenic. If the ore be mixed with biſmuth, this

metal is reduced, ſpeedily fuſed, and is collected at the bottom of the furnace; the cobalt remains in the ſtate of black pulverulent oxide, which, when mixed with two or three times its weight of flint, ignited and pounded, forms the kind of grey powder ſold in commerce under the name of zafre. This being fuſed with three times its weight of black flux, a ſmall quantity of oil, or tallow, and muriate of ſoda, in a lined crucible, is often uſed in the laboratories of chemiſtry to obtain the metallic cobalt when its ore is not to be procured. It is neceſſary, indeed, to uſe much flux, and a very ſtrong fire, to reduce and liquefy this metal ſo as to obtain it in the form of a button; it is alſo frequently impure, by mixture with iron, arſenic, and nickel; biſmuth is alſo ſeparated: ſo that we ought not to have recourſe to this mixed oxide, excepting when we cannot procure the pure ore of cobalt. We may waſh it before reduction and fuſion in order to carry off the ſilex, and leave the oxide alone. In this manner near one half of the maſs is ſubtracted, which is earth, and the metallic oxide, remaining after the waſhing, affords one fourth of its weight of the metal.

E. *Oxidability by the Air.*

17. Cobalt oxides without its being neceſſary to fuſe it; for it is ſufficient that it be heated and ſlightly ignited in a ſhallow veſſel, or large

teſt; by agitation in the air, its powder loſes its ruddy colour and brilliancy; it firſt becomes of a deep grey, which gradually becomes black, or rather of a blue, ſo intenſe, that it appears black. By a very violent fire this laſt oxide flows into a blue-black glaſs. Cobalt fuſed with the contact of the air, becomes covered with a tarniſhed pellicle, which is merely a commencement of oxidation, and affords the ſame black powder when heated and agitated for a long time in the atmoſphere.

18. The temperature at which fuſed cobalt may be inflamed, has not yet been determined. It appears to abſord 0,40 of its original weight of oxide by oxidation. Citizen Guyton placed it in the firſt rank of oxidability, beſide manganeſe, iron, zinc, and nickel. The characteriſtic and moſt uſeful property of its oxide is, that of affording a blue glaſs by fuſion, and of very intenſely colouring with the ſame tinge all the ſubſtances with which it may be vitrified; it is eaſily reducible by charcoal, which takes from it at the red heat, its oxigen; it does not give out this principle by the mere action of caloric or light.

F. *Union with Combuſtibles.*

19. The combination between azote, hidrogen, carbon, and cobalt, is not known, though it is not improbable, that theſe combinations exiſt.

20. Pelletier has aſcertained the union of cobalt with phoſphorus. By projecting ſmall pieces of phoſphorus upon cobalt, ignited in ſmall fragments in a crucible, the cobalt immediately becomes fuſed; in this manner it abſorbs about a fifteenth of its weight of phoſphorus, and exhibits on its ſurface a cruſt of violet roſe-coloured oxide. The ſame phoſphoret of cobalt is formed by fuſing, in a crucible, a mixture of equal parts of vitreous phoſphoric acid and cobalt, mixed with an eighth of their weight of powder of charcoal. In proportion as the acid paſſes to the ſtate of phoſphorus, it unites with cobalt, which becomes melted; and at the bottom the phoſphoret of cobalt is obtained, covered with a glaſs of a beautiful blue. The phoſphoret of cobalt, prepared by either of theſe proceſſes, is exactly the ſame compound: it is of a bright metallic colour, whiter than cobalt, inclining to blue, brittle, and ſlightly needled in its fracture. It is more brittle than the metal, and loſes its brilliancy in the air; when heated and kept in fuſion by the blow-pipe, the phoſphorus is diſengaged from the metallic globule, and burns on its ſurface; and at length there remains a vitreous globule of a deep blue; which proves that the cobalt is ſpeedily oxided by the fuſion and combuſtion of the phoſphorus in the air, in proportion as this laſt principle is diſengaged.

21. Sulphur does not unite with cobalt but with difficulty, ſo that the union with theſe two

combuſtible bodies is not known, but they may be combined with the aſſiſtance of the alkalis. This metal is ſoluble in the alkaline ſulphurets in the dry way, and the reſult is a ſulphuret, with large facets of a white or yellowiſh colour, a kind of artificial ore, from which fire diſengages the ſulphur very imperfectly; and which cannot be decompoſed but by the acids.

22. Cobalt, alloyed with many metallic ſubſtances, forms granulated and brittle metals; it unites to arſenic, which it retains with great power, and from which it cannot be cleared but with much difficulty.

G. *Action upon Water and Oxides.*

23. COBALT acts neither upon water nor upon the metallic oxides, neither has this metal ſufficient attraction for oxigen to ſeize it from thoſe bodies.

H. *Action upon the Acids.*

24. ALL the acids attack either cobalt or its oxide. The concentrated and boiling ſulphuric acid is decompoſed by this metal; ſulphureous acid gas is diſengaged; a grey denſe matter is formed inclining to a roſe colour. If this ſpecies of magma be lixiviated, water diſſolves the ſulphate of cobalt, and affords a light grey fluid.

The green ſolution deſcribed by ſome authors is owing to nickel, which cobalt ſometimes contains; but this colour is never ſeen with very pure cobalt: the ſame obſervation applies to the two kinds of cryſtals obtained by this ſolution, which are mentioned by many chemiſts. The ſulphate of cobalt cryſtallizes in ſmall needles, or in tetrahedral priſms, rhomboidal, terminating in ſummits of two faces. This reddiſh ſalt is decompoſable by fire, and alſo affords an oxide of cobalt ſlightly grey, or blackiſh, if urged by a ſtrong heat. It melts, ſwells up, and boils with noiſe before the blow-pipe. The alkalis and alkaline earths decompoſe it, and precipitate an oxide of a yellow colour, inclining to roſe or fleſh-colour; one hundred parts of cobalt afford an hundred and forty parts of this precipitate by the pure alkalis. When the precipitation is made by the alkaline carbonates, 160 parts of precipitate are obtained from 100 parts of carbonate made uſe of. The oxide of cobalt in the form of zafre, is eaſily diſſolved in the diluted ſulphuric acid, and conſtitutes a ſalt ſimilar to that which is prepared with the metal.

25. Cobalt decompoſes the nitric acid with effervefcence, and diſengagement of nitrous gas, particularly with the aſſiſtance of a gentle heat; the metal is oxided and diſſolves in the acid. The ſolution is of a fleſh colour, or deep violet; when concentrated it inclines to brown. By cautious evaporation it affords ſmall reddiſh priſmatic cryſtals, which are deliqueſcent, and

boil upon ignited coal without detonation, leaving a deep red oxide after their decompoſition by fire. The precipitates of this nitrate of cobalt, by the alkalis, reſemble thoſe of the ſulphate, excepting that their colour is more lively and brilliant; and accordingly it is from this ſalt that the oxided cobalt is almoſt always precipitated for enamel and porcelain. An exceſs of alkali re-diſſolves this oxide; ammonia more particularly exhibits that property while the precipitate is ſuſpended in the liquor; nevertheleſs, when it is depoſited and condenſed, ammonia may be uſed to diſſolve the oxide of nickel, with which it may be contaminated. The nitric acid is of all acids that which the leaſt readily diſſolves zafre, or oxide of cobalt, mixed with ſilex.

26. The muriatic acid does not diſſolve cobalt without heat; by the aſſiſtance of heat it diſſolves a ſmall portion; the gas which is diſengaged during this ſolution has not been obſerved; it muſt be hydrogen gas. This acid diſſolves oxided cobalt with great facility; and the more ſtrongly it is oxided the more effectually is the action. By this action it is that the whole of the oxide of cobalt is taken from zafre by the muriatic acid: this acid alſo takes it from the ſulphuric acid; it forms a ſolution of a brown red, which by evaporation affords a muriate of cobalt cryſtallized in ſmall deliqueſcent needles. This ſolution is remarkable for the property of becoming of a beautiful green

when heated; it conſtitutes the moſt ſtriking and the beſt known ſympathetic ink; it muſt be diluted with water until colourleſs. With this fluid writing is made on white paper; the characters thus formed diſappear in drying; but when brought near the fire, the paper ſoon exhibits the letters traced of a fine pea-green colour, which diſappear in cooling, and ſtill preſerve, if they have not been too ſtrongly heated, the property of reſuming the green colour by heat. By too much heat the writing becomes brown, and no longer diſappears, the paper being ſcorched. This ink of ſympathy is more particularly made with the nitro-muriatic acid and zafre. The cauſe of this colouration of the muriate of cobalt by heat has not yet been aſcertained. It was formerly thought to be merely drying which cauſes the green colour to appear, and that it diſappeared by abſorbing the water of the atmoſphere; but this opinion is falſe, ſince the ſolution produces the ſympathetic effect, even if the paper on which the writing is made be put into a bottle, and dipped in boiling water, for it aſſumes the green colour, and loſes it in proportion as the water cools: it is more natural to think that this effect depends on diſoxidation, and that the oxide on cooling reſumes the portion of oxigen which it had loſt. Some chemiſts think that cobalt does not form ſympathetic ink unleſs it contains iron; but this aſſertion is not proved.

27. Cobalt thrown in powder into the oxigenated muriatic acid gas, takes fire, and burns with white ſparks; by this means a pale roſe coloured oxide remains, which may be employed in the arts.

28. The phoſphoric acid diſſolves the oxide of cobalt, and forms a reddiſh fluid, which becomes turbid, and affords a depoſition when the acid is ſaturated. The fluoric acid which diſſolves it alſo, affords cryſtals by well-conducted evaporation. The boracic acid has no action upon cobalt; it may be combined with the oxide, by mixing a ſolution of the nitrate of cobalt with a ſolution of borax. There exiſts a carbonate of cobalt, which is formed by precipitating cobaltic ſalts with alkaline carbonates. We have ſeen, that an hundred parts of this metal, which afford only 140 of precipitate by the alkalis alone, afford 160 parts by the carbonate of ſoda.

29. The metallic acids combine with the oxide of cobalt. We are not yet acquainted with the tungſtate nor molybdate, nor chromate of cobalt; but the arſeniate of cobalt is eaſily prepared, and well known. It is formed by uniting the nitrate of cobalt with the arſeniate of pot-aſh, and of ſoda. Of all the cobaltic ſalts, this is the moſt deep and moſt brilliantly coloured of the roſy red; it very nearly reſembles the ore which was deſcribed in the fourth ſpecies.

I. *Action on the Bases and the Salts.*

30. The alkalis and the alkaline earths have no action upon cobalt; they completely diſſolve, with different degrees of facility, its oxide when ſuſpended or diffuſed in water; they ſerve, or at leaſt may be uſed, to ſeparate thoſe oxides from various ſubſtances, and even from other oxides, which are not ſoluble like this of cobalt, or are leſs ſoluble than they in alkaline ſubſtances.

31. The earths, and particularly ſilex, when fuſed with the oxide of cobalt and fixed alkalis, formed a blue glaſs of ſuch intenſity, that very little of the oxide muſt be employed to admit of tranſparence and a perceptible blue colour: if this be not attended to, the glaſs will be opaque and appears black.

32. There is no action between cobalt and the ſulphates. The nitrates burn and oxide them at an elevated temperature without detonation or perceptible flame, and this action is frequently uſed to prepare the oxide of cobalt employed in enamels, pottery, and particularly porcelain. The grey ore of the metal may be treated in this manner, after which, the reſidue of the detonation muſt be well waſhed to carry off all the ſalts, and the roſe or fleſh-coloured oxide thus obtained, muſt be long ſuſpended in water, until it be very fine, of great purity, and of a very homogeneous colour. The ſame

effect is obtained by the ſuper-oxigenated muriate of pot-aſh, which detonates by percuſſion, when mixed with one third of its weight of cobalt in powder.

K. *Uſes.*

33. Cobalt is not uſed in its metallic form; it is employed only to make blue glaſſes or enamels. Zafre is uſed for coarſe enamels, common potteries, and earthen ware, in which employ it is mixed with vitreous fluxes. In the manufactories of porcelain, much care is taken to have the oxides of cobalt very pure and attenuated. The grey ore is choſen well cryſtallized; this is roaſted, and treated with the nitric or muriatic acid, or otherwiſe it is burned with nitrate of pot-aſh; the oxide is carefully waſhed with much water: by which treatment, the oxide is obtained in violet-coloured powder, very fine, and very homogeneous, which affords the pureſt and moſt beautiful blue, when treated with a vitreous flux. The elegant blue of the porcelain of Sevres, is of this nature.

34. At the manufactories in the vicinity of the cobaltic mines, a vitreous blue is prepared in a fine powder, which, in commerce, is known by the name of azure, or powder-blue. The zafre mixed with ſilex, is fuſed with alkali ſo as to afford a deep blue glaſs, called ſmalt. This ſmalt is reduced to powder in mills, and the powder elutriated in large veſſels of water. The

firſt portion which falls down is the heavieſt, and is called coarſe azure. In ſucceſſion, four other azures of different tenuity are obtained; the laſt, which is the fineſt of all, is named azure of four fires. It is particularly uſed in the preparation of the powder-blue.

35. We muſt remark, in concluding the hiſtory of this metal, that cobalt reſembles ſeveral of the preceding metals, particularly tungſten and molybdena, in its property of affording a blue colour; nevertheleſs, the blue afforded by the others is only tranſient, and does not take place by fuſion, whereas, this is conſtant, and always the product of vitrification. Theſe analogies, and the extreme difficulty of purifying cobalt, have induced ſeveral chemiſts to ſuppoſe, that this metal is only an alloy; but it is certain, as Bergmann obſerves, a man who has carried the philoſophy of chemiſtry to the higheſt point, that thoſe opinions reſpecting the pretended alloy of cobalt muſt be conſidered as erroneous, ſo long as there are no poſſible experiments to prove, that cobalt can be ſeparated into two different metals in known proportions, and that by alloying theſe metals in the ſame proportions, true cobalt can be fabricated. As no ſuch proofs exiſt, the notions of authors in this reſpect are inadmiſſible hypotheſes, and we muſt, until theſe proofs ſhall be exhibited, conſider cobalt as a peculiar metal, poſſeſſing very diſtinct characters and properties not to be obſerved in any other metal, nor in any alloy whatſoever.

ARTICLE IX.

Concerning Nickel.

A. *Hiſtory.*

1. HIERNE was the firſt who mentioned the particular ore which contains nickel, in a work on the art of diſcovering metals, publiſhed in 1694. The ore was named kupfernickel or falſe copper. Henckel conſidered it as a ſpecies of cobalt, or arſenic mixed with copper. Cramer referred it alſo to the copper and arſenical ores, though he did not obtain copper from it; which is alſo confeſſed by Henckel.

2. The opinion which claſſed kupfernickel among the ores of copper, was generally adopted till the middle of the 18th century. In the year 1751 and 1754, Cronſtedt, a celebrated Swediſh mineralogiſt, the firſt who formed the uſeful project of claſſing foſſils according to their chemical nature, ſhowed, in the Memoirs of the Academy of Stockholm, that a new metal might be extracted from this ore, very different from all thoſe before known, which he named nickel. This opinion was ſoon adopted by the greater part of mineralogiſts, though ſeveral, and particularly Citizens Monnet and Sage, have continued to ſupport, though without deciſive experiments,

periments, that nickel is cobalt alloyed with arſenic, iron, and copper.

3. Bergmann endeavoured to reconcile theſe opinions by a ſtrict examination of nickel; he gave a diſſertation on this metal, in the month of July 1775, under the form of a theſis, ſupported at Upſal by Mr. Ardvidſon, his pupil. He particularly endeavoured to determine whether nickel be truly a peculiar metal; and in this examination, he diſplayed all the reſources of the art, and all the ſkill of a great maſter. The general reſult of this great work was, that nickel which does not contain a particle of copper, is uſually alloyed with cobalt, arſenic, and iron, which cannot be ſeparated, but with the greateſt difficulty; but that, notwithſtanding the impoſſibility of purifying it completely, its properties are in ſo many reſpects different from thoſe of all the other metals, and theſe properties becoming more diſtinct and intenſe, in proportion as it is purified, it is abſolutely neceſſary to conſider it as a very diſtinct, and determinate ſpecies.

B. *Phyſical Properties.*

4. Nickel, in the higheſt ſtate of purity to which it can be brought, is of a yellowiſh white, or reddiſh white of variable brilliancy, and granulated texture. This texture is lamellated only in the caſe of impurity. Its ſpecific gravity approaches nearly to 9000, according to Berg-

mann. Citizen Guyton gave it only 7807. Bergmann, in various places, affirms, that it is ſemi-ductile, and Citizen Guyton ranges it with zinc, with regard to this property; but it is evident there is an error, or at leaſt, a great uncertainty in this eſtimation, ſince the celebrated Swediſh chemiſt remarks, that, notwithſtanding the greateſt purification, this metal contains more than a third of its weight of iron: it therefore appeared to him impoſſible to determine with exactneſs, its real ſpecific properties, becauſe, as he obſerves, the iron muſt modify them in a certain reſpect. It is therefore evident, that we ought to attribute the ſemi-ductility and magnetic property, particularly the polarity, which nickel ſometimes exhibits to this metal, namely, the iron. Citizen Guyton gave it the ſecond claſs for hardneſs, after manganeſe and iron, which occupy the firſt ſtation in this table, and upon the ſame line as platina; it is very difficult to fuſe, and the ſame chemiſt places it along with iron. Its dilatability and conducting power as to caloric, have not been yet determined, neither has it been yet obtained in the cryſtallized ſtate. Its ſmell or taſte have not been determined, though it is probable, that it poſſeſſes peculiarities with regard to both.

C *Natural Hiſtory.*

3. There are three ores of nickel, very diſtinct and very eaſy to be diſtinguiſhed.

Species I.

Sulphuret of Nickel.

THIS is the moſt abundant and moſt eaſy to diſtinguiſh. It has been denominated kupfer-nickel by Hierne, who firſt deſcribed it; it is of a reddiſh yellow colour, of little brilliancy, reſembling tarniſhed copper, with which its aſpect always tends to confound it. Its fracture is rugged, unequal, and its texture fine-grained and cloſe; it eaſily loſes its brilliancy in the air, becomes tarniſhed, browniſh, and at length covered with greeniſh ſpots. It forms a vein in the earth. This ore has not been exactly analyzed; it is known, however, that it contains ſulphur, nickel, arſenic, cobalt, and iron. The ſulphuret of nickel exiſts in Sweden, in Saxony, in France, &c. It is very far from being as ſcarce as Bergmann pretended, ſince it is found in tons at many of the druggiſts in Paris.

Species II.

Ferruginous Nickel.

I GIVE this name to an ore, which Baron de Born has deſcribed in his catalogue of the cabinet of Madamoiſelle de Raab, under the denomination of nickel alloyed with iron, without arſenic or cobalt, and which he ſays was found at Joachim in Bohemia. Its texture is foliated, and it is formed of rhomboidal plates applied each other; its recent fracture is of a pale yellow, which becomes black by the contact of the air.

SPECIES III.

Oxide of Nickel.

IT is of a bright and agreeable green or greeniſh colour. It is commonly found at the ſurface of the ſulphuret of nickel, which it ſometimes covers entirely, like ſuperficial coating; it is not known either alone or ſolid, or in any regular form, it is probable, that it contains carbonic acid, from the property which Cronſtedt attributes to it. It is this oxide which colours the praſe, according to Klaproth's analyſis. It is frequently mixed, or, as it were, interrupted by a powder, or efflor eſcence of a whitiſh colour. Mr. Kirwan ſuſpects its exiſtence in ſome ſpecies of ſlate and horn-ſtone, becauſe theſe ſtones colour the nitric acid of a beautiful green.

Beſides theſe three ſpecies, Bergmann aſſerts, that it is not rare to find native nickel, or nickel with very little ſulphur, but combined with

iron,

iron, cobalt and arſenic, and that it exiſts, thus mineralized by ſulphuric acid. Rinman alſo affirms, that nickel has been found native in Heſſe; it is heavy, of a deep red, forming a kind of product of the furnaces among the materials from which nickel may be extracted. It is conſidered as an alloy of cobalt and biſmuth, by the medium of nickel.

D. *Assays; Metallurgy.*

7. THE ore of nickel is reduced after the manner of Cronſtedt, by firſt roaſting it to drive off the ſulphur and arſenic; by which treatment it loſes one third or half its weight. After this operation, it is found of a green colour, which is deeper the more abundant the nickel: it ſometimes is ſeen during the roaſting, when it is left without agitation, that corali-form, hard vegetations are formed, which are ſonorous, when ſtruck. The roaſted ore is mixed with two parts of black flux, then placed in a crucible covered with muriate of ſoda, and heated by fuſion in a forge-furnace. After the apparatus is cold, a metallic button is found under brown, blackiſh or blue ſcoria, which conſtitutes from the tenth to the half of the original weight.

8. But the firſt metal thus obtained, notwithſtanding the ſtrong action of heat applied to the ore, is very far from being pure; it is ſtill an alloy of nickel with cobalt, arſenic, and particularly iron, and is attracted by the load-ſtone. It is even from the various proportions of this

metal, that nickel acquires its variety of ſpecific gravity and of grain, either irregular or in plates, and of a colour, which inclines from red to yellow. The metal obtained by Cronſtedt in 1750, was very far from being pure; he deſcribed it as breaking with large plated fracture, and Bergmann had an opportunity of examining a portion fuſed by this mineralogiſt, which was found in the collection made, and left by Swab to the academy of Upſal. The care, the patience, and the ſagacity exhibited by Bergmann in his attempts to purify nickel, are unequalled, and nothing can better ſhow at the ſame time, the almoſt inſurmountable difficulty of obtaining it in a ſeparate ſtate, than the reſult of his numberleſs and indefatigable aſſays made upon the metal extracted by Cronſtedt himſelf. As this is the moſt eſſential part of its hiſtory, I ſhall enter into ſome detail reſpecting the experiments of Bergmann, in order to ſhow the properties he diſcovered in this metal in his attempts to purify it. He ſubjected it to ſix ſucceſſive roaſtings and ſcorifications, each of which laſted from ten to fourteen hours, and after each ſcorification, he reduced it with black flux. By this treatment, it emitted vapours of arſenic, and a white vapour which had not the ſmell of garlic; the powder of charcoal which he added in his operations, facilitated the diſengagement of the arſenic; nevertheleſs, after theſe ſix roaſtings and graduated reductions, the nickel, though much diminiſhed in weight, emitted a ſmell of arſenic when heated, and it was attracted by the magnet. Bergmann roaſted it a ſeventh time by a violent heat during fourteen hours, adding powder of charcoal, without drawing off any arſenic, or occaſioning any loſs of its weight. The oxide thus obtained, was of a reddiſh-yellow colour, with a few traces of the green tinge. By this reduction he obtained, under the ſcoria which contained no iron, a very ſmall globule which was ſtill attracted by the load-ſtone.

9. The treatment with ſulphur, which appeared to Bergmann to have a great attraction for nickel, and which he hoped might ſeize that metal, and ſeparate it from the iron, was not, however, attended with greater ſucceſs than the former proceſs. By fuſing the metal obtained by Cronſtedt with ſulphur, and a ſmall quantity of borax, he obtained a red maſs inclining to yellow, which, with eight hundred parts of metal, acquired the weight of ſeventeen hundred. He ſcorified half this maſs, ſo as to exhibit the vegetations which the oxide of nickel uſually affords; he obtained eight hundred and fifty-two parts of this oxide, which, when fuſed with the other part which had not been ſcorified, afforded ſulphuret of nickel of a yellowiſh white, weighing eleven hundred and two; in this caſe, there were near ſix hundred parts loſt. This ſulphuret, after four hours roaſting, became covered with vegetations; the addition of charcoal diſſipated the arſenic; he obtained an oxide

of a bright green, weighing 1038, which, by reduction, afforded 594 parts of a metal, much attracted by the magnet, very ductile, and very refractory. This metal being fuſed again with ſulphur, one half then ſcorified and fuſed with the other ſulphurated half, and this whole maſs roaſted for four hours and again reduced, afforded a metal, red without, of an aſh-coloured white within, very brittle, and of which the ſpecific gravity amounted to 7,170. When mineralized a third time, and treated again in the ſame manner as the two firſt times by roaſting with charcoal-power for twelve hours, till it exhibited no longer any trace of the preſence of arſenic, it afforded an oxide of an aſh-green colour, from which, by reduction with the moſt violent fire of a forge, was obtained a metal ſo refractory that it could not be fuſed into a button: it was under a ſcoria, of a hyacinth colour. It weighed 8,66. It was attracted by the magnet; its ductility was ſo remarkable, that it was extended to the length of 3½ times its diameter under the hammer; its colour was reddiſh-blue; it was found to be ſoluble in a deep green in the nitric acid, and in a blue colour in ammonia. This metal heated to redneſs for four hours, became covered with a cruſt of oxide of iron, which being detached by the hammer, a greeniſh powder was found under it: one hundred parts of this cruſt being roaſted for ſeven hours with charcoal, exhibited no longer any trace of arſenic, was increaſed by five parts, and afforded by reduction a metal of the weight of ſeventy-two parts, of a faint red colour, ſemi-ductile, entirely attracted by the magnet, and the ſpecific gravity of which amounted to 8,870. It is evident from all thoſe details, that Bergman had ſucceeded in ſeparating the arſenic, and the cobalt from the nickel, but that he had not inſulated the iron, to which we may attribute the ductility of the metal. Thus ſulphur has not been of greater utility in refining nickel, than the other ſcorifications with charcoal, and the multiplied reductions deſcribed No. 8.

10. Knowing that the alcaline ſulphurets diſſolved cobalt better than nickel, Bergmann was led by analogy to believe that theſe compounds might act in the ſame manner upon the iron, and conſequently ſerve him to deprive the nickel of it: but his hopes were diſappointed. The nickel of Cronſtedt, (the reader knows that I apply this name to that which is the product of a firſt reduction after the firſt roaſting of its ore), already united with ſulphur, was fuſed with more than thirty times its weight of ſulphuret of pot-aſh; the maſs, waſhed in hot water, afforded by an acid a precipitate, which being roaſted till the total ſeparation of the ſulphur was effected, was in the ſtate of a cineritious powder weighing more than half of the firſt metal. The undiſſolved portion, in which he hoped to find the nickel, being

equally deſulphurated by roaſting, became no leſs cineritious, and gave by reduction a brittle metal, little attracted by the magnet, but which became ſuſceptible of being attracted by it after having been fuſed with borax. The ſame experiment being made with the ſulphuret of lime, alſo afforded a ferruginous nickel which adhered very ſtrongly to the ſulphur. When nickel was fuſed with alcaline ſulphuret, in another experiment, and at the moment of fuſion, nitre was added to it, in a quantity barely ſufficient to deſtroy only a ſmall portion of the ſulphuret, this left the metal to be precipitated to the bottom of the veſſel: nickel treated in this manner is found to be deprived of cobalt, but ſtill charged with iron. Bergmann obſerves on this occaſion that by the ſame proceſs the nickel is precipitated by cobalt, which has greater attraction for the ſulphuret than the former has, and that being thus ſeparated from its ſolution in the fuſed ſulphuret by iron, copper, tin, lead, or even cobalt, nickel is not ſuſceptible of being attracted by the magnet; but according to him, it would be a miſtake to believe it exempt from iron; as this latter metal, the properties of which are only diſguiſed by foreign ſubſtances, and undoubtedly by the ſulphur, becomes again magnetic in proportion as we deprive it of them by ſubſequent means.

11. After the failure of the preceding means, Bergmann had recourſe to nitre, in hopes of ſcorifying and ſeparating the foreign metals combined with the nickel, which appeared to him to be oxidated with greater difficulty, and to be diſoxidated more eaſily than they. One part of Cronſtedt's nickel, being thrown upon twelve parts of fuſed nitre, emitted ſome ſlight ſparks; arſenical vapour was ſoon exaled; the ſides of the crucible were covered with a blue cruſt of cobalt, and there remained at the bottom a greeniſh matter. Twelve parts of nitre added to this matter, and fuſed with it for the ſpace of an hour, ſtill tinged the crucible with a blue colour, and the maſs at the bottom became of a brown green colour, much leſs abundant than the firſt time. A third addition of nitre in the ſame quantity left a grey ſcoria, which gave no metal with the black flux, but merely ſcoria of a hyacinth colour, ſpotted with blue, which gave a green tinge to the nitric acid, were converted into a jelly, and left by evaporation a greeniſh oxide. In a third analogous experiment, the green powder, being lixiviated and treated with half a part of black flux, an eighth of lime, and an eighth of borax, gave a metal of a yellowiſh-white colour, attracted by the magnet, ductile, and weighing 9,000. Bergmann concluded from this kind of experiment, that nitre was very proper for indicating and ſeparating the ſmalleſt portion of cobalt contained in the nickel, but that it left

in it the iron of which it could not deprive it.

12. As muriate of ammonia is known to be very proper for ſeparating iron, Bergmann, tried alſo this new means; he diſtilled one part of oxide of nickel, deprived of cobalt ſufficiently to give no longer the blue colour to borax, with two parts of ſal-ammonia; he obtained a cineritious, white ſublimate, accompanied with a little ammonia; the bottom of the retort had aſſumed the deep hyacinth colour; the reſiduum conſiſted of two layers. The upper layer was yellow, ſcaly, brilliant like maſſive gold, yielding with borax a glaſs of a hyacinth colour, without affording metal, attracting the moiſture of the atmoſphere, becoming green and conſiſtent like butter; being lixiviated, it left a powder having the characters of an oxide of nickel, and the green aqueous ſolution was rendered blue by ammonia, without affording any indications of iron. The inferior layer conſiſted of an oxide of nickel, little charged with muriatic acid, blackiſh, of a ferruginous brown towards the bottom of the veſſel. This oxide converted borax into a hyacinth-coloured glaſs, and afforded by reduction a brittle metal, of a reddiſh-white colour, ſcarcely ſuſceptible of being attracted by the magnet. The ſame metal, treated ſucceſſively by four other ſublimations, with muriate of ammonia, the inferior layer being lixiviated and reduced each time, yielded, at the end, and in the laſt reduction,

tion, a white brittle metal, little, though ſtill ſuſceptible of being attracted by the magnet. Bergmann obſerves that each ſublimate was very white, and that it afforded not the ſlighteſt indication of iron by the tincture of the nut-gall.

13. Bergmann, not diſcouraged by the failure of all his attempts with proceſſes in the dry way, occupied himſelf afterwards with the ſeparation of the different metals with which nickel is alloyed, by proceſſes in the humid way. The nitric ſolution of the nickel of Cronſtedt occupied him for a conſiderable time. By calcining the ſolid nitrate of nickel with charcoal-powder, much arſenic was diſengaged, and he obtained, by the reduction of the reſiduum, a grey metal, ſemi-ductile, but ſtill ſuſceptible of being attracted by the magnet; when rediſſolved in nitric acid, and reduced four ſucceſſive times, it afforded a metal always magnetic. At the fifth calcination of this nitrate of nickel, its oxide was diminiſhed in ſuch a manner that he found it impracticable to reduce it; which proves that nickel is volatilized in its oxidation by the nitric acid, without its being thereby deprived of its ſuſceptibility of the magnetic attraction.

14. Finally, the celebrated Swediſh profeſſor tried, as a laſt means, the ſolution of the oxide of nickel in ammonia, in order to ſeparate from it the oxide of iron. After having diſſolved ſome of Cronſtedt's nickel in nitric acid, and precipitated its oxide with pot-aſh, he treated it

with ammonia, which diſſolved at leaſt a ninth of its weight; this reſiduum, which was of a black colour, inclining to green, yielded by reduction, a ſcaly metal, brittle, of a clear white colour, little ſenſible to the magnet, the ſpecific gravity of which amounted to 9,333; it was eaſily fuſible, by which operation it was again rendered ſuſceptible of being attracted by the magnet, and being diſſolved in nitric acid, it yielded a blackiſh powder, inſoluble; evaporable with a ſmell of ſulphur upon the coals. The blue ammoniacal ſolution, when evaporated to dryneſs, yielded nearly one half leſs of reſiduum than it had taken of matter from the oxide of nickel. This powder afforded, by reduction, a very ſmall quantity of metal, of a whitiſh colour, ſemi-ductile, ſtrongly attracted by the magnet, and having a ſpecific gravity of 7000; the ſcoria of which contained much oxide of nickel, colouring borax with a hyacinth tinge, and affording by its reduction a metal, which being fuſed with the preceding, became ſo refractory that it was impoſſible to treat it. Though the experiments with ammonia did not ſatisfy the author, they however afforded very ſingular reſults; ſuch as the conſtant ſolution of the oxide of iron with that of nickel, the blue colour of this ſolution which, though analogous to that of the oxide of copper, has a very different caſt, and eſpecially the loſs of a great quantity of oxide of nickel, which Bergmann does not ſeem to have ſufficiently regarded.

In a word, the narrative of theſe laſt experiments, which ſhow this author to have been fatigued and embarraſſed, notwithſtanding the zeal and ardour which animated him might lead us to think, as well as that of ſeveral of the preceding, either that nickel cannot by any means be purified of iron, or that this ſingular metal is itſelf ſuſceptible of being attracted by the magnet, and that in this property it reſembles iron, whilſt in many others it ſeems to approach to the nature of copper.

15. After having deſcribed in a detailed manner, theſe different and numerous experiments, as they conſtitute almoſt excluſively the exact chemical hiſtory of nickel, I ought alſo to preſent the reader with the inferences which the illuſtrious Bergmann deduces from them, in paragraphs XI and XII of his Diſſertation. The firſt is, that the ſulphur adheres to nickel the leaſt, and the arſenic the moſt ſtrongly, but that we may ſeparate it completely by roaſting with charcoal; that the cobalt remains longer concealed in it, and that we frequently find traces of it when it was not ſuſpected to be preſent, by means of nitre which ſeparates it in a blue oxide; that the blue caſt given to borax is owing to the manganeſe; and laſtly, that iron is of all the metals the moſt intimately combined with nickel, ſince it cannot be entirely extracted from it by any known means.

16. As by all the proceſſes of purification, nickel ſhows to the laſt the preſence of other me-

tallic ſubſtances, ſeveral chemiſts have thought this metal to be nothing more than a natural alloy of arſenic, cobalt, copper and iron. Bergmann diſcuſſes, according to his experiments, the queſtion relative to this ſubject. He ſhows that we may completely deprive nickel of arſenic; that it hardly ever contains copper; that it differs from cobalt in a great number of its properties; that the more we ſeparate the latter, the more it aſſumes the properties by which it is diſtinguiſhed. As to the preſence of iron, he agrees that it is more natural to find great analogies between nickel and this metal; he ſhows in how many properties theſe two metals approach each other, as well as cobalt and manganeſe; but he, neverthelefs, concludes, that nickel preſents too many peculiar properties to be confounded with iron, and that as long as the latter has not been brought into the ſtate of the former, nor their real identity proved, it would be overturning all the foundations of philoſophy to build upon vague appearances, and fallacious analogies.

17. He proves, moreover, the truth of this aſſertion by relating a conſiderable number of experiments on the alloys of iron and copper, of iron copper and arſenic, of iron copper and cobalt, and of theſe four metals together in very various proportions; experiments in which he has never been able to obtain a metal ſimilar to nickel. Though ſome of the properties of theſe alloys at firſt preſented certain analo-

gies with nickel, he ſoon found, by a more thorough examination, that this was only a very fallacious appearance; and that there was no real relation between the alloy and the metal which he had attempted to imitate.

No metallurgical works are eſtabliſhed upon the ores of nickel, and metallurgiſts do not yet place any value upon this ſpecies of mineral.

E. *Oxidability by the Air.*

18. Nickel is very difficult to be oxided by the action of caloric and of the air. When it is heated under a mufle, and conſtantly agitated, it only aſſumes a dark colour. However, by long expoſure to moiſt and cold air, it becomes covered with an efflorescence of a clear green colour, of a very particular and diſtinct tinge. It is this efflorescence which is found upon the ſurface of the ſulphureous ores of nickel, the tinge of which being very remarkable, and very different from that of copper, enables us to diſtinguiſh them with eaſe and certainty. This green oxide gives borax a hyacinth colour, and imparts the ſame tinge to the ammoniacal phoſphate of ſoda, which becomes violet by the action of nitre: a large quantity of this oxide gives this ſalt a blood-red colour during fuſion, which becomes paler by cooling.

F. *Union with Combuſtible Subſtances.*

19. SULPHUR combines very eaſily with nickel, and forms an artificial ore which is not altogether ſimilar to its natural ore or Kupfer-nickel. The artificial ſulphuret of nickel is hard, yellow, with ſmall brilliant facets. When ſtrongly heated in the air, it emits very luminous and inflamed ſparks.

20. Nickel is ſuſceptible of uniting with phoſphorous. Pelletier has acquainted us with the phoſphoret of nickel; he prepared it either by the reduction of the vitreous phoſphoric acid with the addition of charcoal, after having mixed theſe two ſubſtances with the nickel, or by throwing phoſphorus upon nickel heated to redneſs in a crucible. This increaſed in weight by one fifth, and a ſmall portion of phoſphorus was ſeparated from it as it cooled. The phoſphuret of nickel is of a more brilliant and purer white than nickel; its texture is needle-formed; when heated before the blow-pipe the phoſphorus burns at its ſurface in proportion as the metal is oxided. Pelletier has obtained the ſame reſult from ſpeiſs.

21. Nickel enters into alloys with many metals: it has been ſeen that it always contains arſenic, often cobalt, and conſtantly iron. It has been ſeen, that in the latter alloy, the iron, though fuſed, is ductile, which has juſtly been remarked as an extraordinary circumſtance by Bergmann. Arſeniated nickel gives a blue colour to glaſs, according to Citizen Monnet.

Bergmann attributes this property to the cobalt, which the arſenic ſeparates from the nickel.

G. *Action upon Water and the Oxides.*

22. It would be natural enough to imagine that nickel, which has ſo much analogy with iron, ſhould exert an action upon water; but there is no experiment which proves this to be the fact, or which even authorizes us to ſuppoſe it.

23. We may aſſert that nickel exerts no action upon the metallic oxides, as moſt of the metals have, on the contrary, the property of precipitating nickel from its ſolutions, as will ſoon be ſhown.

H. *Action upon the Acids.*

24. All the acids act upon nickel or its oxides. All the combinations of this metal are conſtantly green, and of a clear and very brilliant colour, which is very remarkable and very different from the green afforded by certain metals. This is one of the richeſt and moſt beautiful colours that can be exhibited. The fixed alkalis precipitate all theſe ſolutions in a greeniſh white, and communicate a yellow colour to the oxide which they re-diſſolve.

25. The ſulphuric acid, concentrated, and diſtilled upon this metal, is decompoſed; ſulphureous gas is diſengaged, and a grey maſs remains, which diſſolves in water, and immediately communicates to it its beautiful green colour. By evaporating this ſolution we obtain

foliated cryſtals, of the colour of a pale emerald. I have ſeen cryſtals of ſulphate of nickel prepared by the ingenious proceſſes of Citizen Leblanc, in beautiful ſquare priſms, very thick and long, of a rich deep-green colour, terminated by ſummits obliquely truncated. The ſulphuric acid alſo diſſolves the oxide of nickel with facility. Bergmann ſays that this ſalt forms itſelf in decahedrons, or yields compreſſed aluminiform cryſtals, with truncatures at the two oppoſite ſummits.

26. The nitric acid oxides and diſſolves nickel with the aid of heat; it effects, without effervеſcence, the ſolution of the oxide of this metal; it is of a green colour, and gives deliqueſcent rhomboidal cryſtals, which are decompoſed by the action of fire, and leave, by ſtrong calcination, a blackiſh oxide, after having yielded oxigen gas. Expoſed to dry and hot air, the nitrate of nickel loſes its water of cryſtallization, and even its acid, ſo as to leave a greeniſh oxide, in which we frequently find a ſmall quantity of iron and of arſenic.

27. The muriatic acid diſſolves nickel and its oxide more ſlowly than the nitric acid: this ſolution, which is green and brilliant, affords irregular and undetermined cryſtals. The muriate of nickel is decompoſable by the action of fire, and even of the air in the courſe of time. The action of the oxigenated muriatic acid upon this metal has not yet been tried.

28. The

28. The other acids exert only a feeble and ſlow action upon nickel. The fluoric acid charges itſelf with difficulty with its oxide, and gives cryſtals of a clear green colour. The phoſphoric acid has only a feeble attraction for this oxide; this ſolution has ſcarcely the ſlighteſt greeniſh tinge, and affords no cryſtals. The boracic acid does not unite with it unleſs by double elective attraction. The liquid carbonic acid, left for a long time in contact with nickel, afforded Bergmann no certain ſign of its ſolution. The arſenic acid forms with nickel a green ſaline maſs, which is obtained by double attractions; it ſeparates from the nickel a ſaline and little ſoluble powder. The action of the tungſtic, molybdic, and chromic acids upon nickel is not known.

I. *Action upon the Baſes and the Salts.*

29. The arid earths, ſilex, alumine, exert no action upon nickel; treated by alkaline fluxes, with its oxide, they become tinged with a hyacinth, or an orange-red colour; if it contain much arſenic, or cobalt, the glaſſes which it tinges turn to the blue or violet colour.

30. The fixed alkalis diſſolve its oxide in little abundance, and aſſume with it a yellow colour; but this oxide is very ſoluble in ammonia, which does not act upon the metal. The ammoniacal ſolution is of a deep blue colour, which has not the livelineſs and luſtre

of that of copper, concerning which we ſhall ſpeak hereafter; it has its characteriſtic tinge, which an experienced chemiſt ought eaſily to recogniſe. When evaporated, it precipitates a blackiſh-brown powder, and paſſes from the blue to the green colour. Moſt of the metals ſeparate the nickel from it. This great ſolubility of the oxide of nickel in ammonia ſerves ſometimes to ſeparate it from that of cobalt.

31. Nickel acts, amongſt the ſalts, only upon the genera of the nitrates, the ſuper-oxigenated muriates, the phoſphates and the borates. The two firſt burn it and reduce it to the ſtate of oxide; it fuſes with the two others, combines with them, and gives them a hyacinth colour. It may be remembered that the nitrate of pot-aſh, which detonates feebly with nickel, enables us to find in it, by blue ſcoria, cobalt, of which no other means can ſhow any trace. The ſuper-oxigenated muriate of mercury burns this metal in a ſtill more lively and complete manner, and may ſerve to purify it, as alſo to make the analyſis of its ores, when the uſe of this important ſalt ſhall be better known, and more generally diffuſed than has hitherto been the caſe. Theſe two ſaline ſubſtances cauſe the hyacinth colour of the oxide of nickel to re-appear, or augment it with much intenſity in glaſſes, which, on account of the ſmall quantity which they contain of it, and even on account of their vitrification itſelf, preſent no trace of it, or exhibit only a very ſlight tinge.

K. *Uſes.*

32. Nickel has hitherto been applied to little or no uſe: it cannot, however, be doubted, that it may be employed with great advantage in the manufacture of enamels, glaſs, porcelain, and pottery. It is even probable, that it may be an ingredient in the ſecret proceſſes of ſome manufactures, as large proviſions of it are frequently found with the druggiſts of Paris, who procure it from Saxony only in proportion to the demand which is made for it.

33. When new inveſtigations ſhall have been made relative to this ſingular metal, which deſerves all the attention of chemiſts; when the means of purifying it ſhall have been diſcovered, which I believe to be more eaſy than Bergmann thinks, it will become very advantageous, and undoubtedly much employed. Hitherto, it has been only a ſpecies of alloy for chemiſts. If after its purification, it exhibits the conſiderable ductility of which Bergmann has ſpoken, it will be neceſſary to remove it from the rank which I have aſſigned it in the Syſtem of Chemiſtry, and place it immediately beſide zinc. I have not yet placed it in this rank, but have left it after cobalt, becauſe, with ſome analogies with this metal, it appeared to me, that it muſt owe its ductility to its being alloyed with iron.

ARTICLE X.

Of Manganeſe.

A. *Hiſtory.*

1. THE native oxide of this metal has long been employed in the glaſs manufactories, under the name of *glaſs-maker's ſoap*, on account of its property of whitening glaſs; it was known by the name of *black magneſia* or manganeſe. Its multiplied uſes had given no light reſpecting its intimate nature, and before the exact inveſtigations of which I am about to ſpeak, no leſs erroneous, than different opinions concerning it, had obtained amongſt mineralogiſts. Moſt naturaliſts conſidered this ſubſtance as a poor and refractory iron ore, undoubtedly, on account of its colour, and the ferruginous oxide with which its ſurface is often covered, or with which its fragments are frequently accompanied in the mines. However, Pott and Cronſtedt, the firſt mineralogiſts who have drawn great lights from chemical analyſes for the knowledge and claſſification of foſſils, did not recogniſe in their experiments the ferruginous nature of the ſubſtance which was called manganeſe. Other mineralogiſts had placed this metallic foſſil amongſt the ores of zinc, without having given any proof of this hazarded aſſertion. Weſtfeld

publiſhed, in 1767, a treatiſe upon this mineral, in which he endeavoured to aſcertain its conſtituent parts, but by experiments ſo inaccurate, that his work is a ſeries of errors, to which, indeed, the period in which he wrote greatly contributed.

Bergmann and Scheele are the firſt chemiſts who, having choſen manganeſe for the object of their inveſtigations, have placed its nature as a particular metal in the cleareſt light. The former has given its hiſtory in his excellent Diſſertation on the white ores of iron, in 1774, and had already, for ſome years, conſidered it as a metal different from all others, on account of its weight, its property of colouring glaſs, that of being precipitated in a white form by the alkaline pruſſiates, and on account of the impoſſibility of either ſeparating from it ſeveral different metals, or of imitating or producing it by alloys. Scheele, induced by Bergmann, who ſhowed all the importance of ſuch an inquiry, to examine with accuracy the native oxide of manganeſe, laid before the Academy of Stockholm, in 1774, after reſearches continued during three years, a memoir which deſerves to be conſidered as a maſterpiece of this able chemiſt, though he has deceived himſelf with reſpect to the theory of the phenomena which this ſubſtance preſented to him. His work contains a numerous ſeries of diſcoveries, which led him to conſider this foſſil as the oxide of a particular metal, very different from all others. It was in the courſe of his labours upon this native metallic oxide that he diſcovered its properties, and the particular nature of barites.

3. Gahn, a pupil of Bergmann, was the firſt who, according to the teſtimony of his maſter, obtained the particular metal contained in the native oxide of manganeſe, and ſince him, almoſt all chemiſts have ſucceeded in extracting it. Mr. Champy was one of the firſt who extracted it in conſiderable abundance in France, from the oxide of manganeſe of la Romèneche, and obtained it in the form of a well-formed button. Mr. Iſleman has publiſhed, in Crell's Journal, a ſeries of experiments upon this metal. M. M. Engeſtroem and Rinman have given, in the Memoirs of the Academy of Stockholm, details concerning ſeveral ores of manganeſe, and have confirmed all the reſults of Scheele. Citizen Lapeyrouſe has given accounts of a great number of varieties of ores of manganeſe, and has eſpecially diſcovered this metal in its native ſtate in France.

4. The French chemiſts, ſince the eſtabliſhment of the pneumatic doctrine, have given a new value to the experiments of Scheele and Bergmann, either by rendering them ſubſervient to the conſolidation of this doctrine, by the fundamental principles of which they are explained, at the ſame time in ſo natural and ſo ſimple a manner, or by pointing out a relation between them, of which their authors had not

been aware. They have ſhown, that no ſubſtance preſents more favourable phenomena than this new metal to the data of the theory of the elaſtic fluids, and they have found in manganeſe, and eſpecially in its oxide, a ſource of proceſſes and experiments which would alone be ſufficient for eſtabliſhing all the fundamental points of this doctrine. The analogy of theſe phenomena with thoſe preſented by other metals, and the combuſtible bodies in general, eſpecially produce the ſtrongeſt conviction in the minds of thoſe who obſerve them. On this account, I ſhall expoſe them with every requiſite elucidation, offering them, particularly as a ſtriking picture of the collective baſes of the French pneumatic theory.

B. *Phyſical Properties.*

5. MANGANESE extracted by the proceſs that ſhall be indicated, is diſtinguiſhed from all other metals by the following properties. It is of a brilliant whiteneſs approaching to grey, which is quickly altered in the air; its texture is granulated, without being ſo fine and cloſe as that of cobalt; its fracture is rough and unequal; its ſpecific weight is 6,850. It holds, together with iron, the firſt rank in the order of hardneſs. It is one of the moſt brittle metals: at the ſame time it is one of the moſt difficult to be fuſed. Citizen Guyton places it immediately after platina, and determines it at the

160th

150th degree of Wedgwood's pyrometer. We know neither its dilatability by caloric, nor its conducting property. It is frequently ſuſceptible of being attracted by the load-ſtone, eſpecially when it is in the ſtate of powder, on account of the iron which it contains, and which is almoſt as difficult to be ſeparated from it as from nickel; it has no perceptible ſmell nor taſte; in communication with other metals, it exerts the galvanic action upon the nervous and muſcular ſyſtems of animals; its colour is extremely variable.

C. *Natural Hiſtory.*

6. ONLY one ore of manganeſe is as yet well known, namely, its native oxide, which ſome modern mineralogiſts, amongſt others Mr. Kirwan, announced as being combined with carbonic acid. This oxide is frequently mixed with iron, barites, ſilex, lime, &c.: it varies alſo by its ſtate of oxidation, or by the proportion of oxigen which it contains. The following are the reſults which Scheele has obtained reſpecting its varieties of colour. The blue oxide is the leaſt oxigenated of all: the green proceeds from the mixture of the preceding with the yellow oxide of iron; in the yellow, the latter is very predominant: the red is more oxided than the preceding ones; the black, on the contrary, is oxigenated in the higheſt poſſible degree.

7. Mr. Kirwan diſtinguiſhes three principal varieties of native oxide of manganeſe, the white, the red, and the black.

A. The white, which contains the leaſt iron and the leaſt oxigen: M. Rinman has found it in ſmall cryſtals, or in rounded maſſes of a ſparry texture in the cavities of quartz; he has found ſome of a yellow colour, covered with a blackiſh and fuliginous incruſtation. Citizen Lapeyrouſe has found it in a ſpongy efflorefcence upon ores of iron, and eſpecially upon the hæmatite. There are carbonates of iron, of a white colour, which contain more of this oxide than that of iron. Every white oxide of manganeſe becomes tarniſhed in the air, and powerfully abſorbs oxigen from it.

B. The red, according to Mr. Kirwan, contains leſs carbonic acid, and more iron than the white; it is, either friable, or hard in carbonate of lime, ſchiſtus, upon the hæmatites, or in lamellated maſſes, radiated or cryſtallized in pyramids, in rhomboids, in ſhort and brittle needles.

C. The black and brown frequently cryſtallized like the red, or in ſolid maſſes of a metallic or a tarniſhed and earthy appearance, mixed with quartz, &c.; it weighs 4,000. To this variety, Mr. Kirwan refers, 1. *The Perigord ſtone*, generally of an obſcure grey colour, very heavy, eaſy to be ſcraped with the knife, though hard and difficult to be broken in pieces, becoming harder, and of a reddiſh-brown colour by calcination, without becoming attracted by the magnet, giving borax the colour of the amethyſt; 2. *Black-wad,* of a deep brown colour, in the form of powder, or ſmall, hard, and brittle maſſes, in which Wedgwood has found 0,43 of manganeſe, 43 of iron, 0,14 of lead, and 0,05 of mica, and which, after having been dried, and kneaded cold with lintſeed-oil, becomes ſpontaneouſly heated and inflamed.

8. Citizen Haüy, who gives only one ſpecies of ore of manganeſe, its native oxide, divides its varieties into two ſections; the one poſſeſſing the metallic ſtate, at leaſt, in the fracture, and eaſily tranſmitting the electric ſpark; the others deſtitute of the metallic ſtate, and tranſmitting the electric ſpark only in a feeble manner.

The firſt have ſome reſemblance with the native ſulphuret of antimony: the diſtinguiſhing character, which is eaſily recogniſed, is that the oxide of manganeſe, rubbed upon a dark-coloured ſtone like the ſlate, and wiped lightly with the finger, leaves a tarniſhed and dull-coloured trace, whilſt the ſulphuret of antimony marks it with a very ſenſible metallic brilliancy.

The ſecond varieties are of different colours, eſpecially black, brown, yellowiſh, red, of different priſmatic forms by diminution, ſolid and compact, tuberculated, in effloreſcence. They yield oxigen gas, like the firſt, and frequently more than thoſe, when heated in cloſe-veſſels.

9. When we compare the different forms and appearances preſented by the numerous varie-

ties of native oxide of manganeſe, we find that the moſt regular, and at the ſame time the moſt brilliant and metalliform, is in tetrahedral rhomboidal priſms, ſtriated and ſeparate, or in needles united into bundles, or in rays and ſtars. Amongſt thoſe which have not the metallic appearance, we particularly diſtinguiſh a brown, blackiſh, and friable efflreſcence, which ſtains the fingers like ſoot; a variety of a dull velvet black; the compact and irregular grey variety, reddiſh-brown, compact, very heavy, cavernous, exhibiting rudiments of ſhining cryſtals in its cavities: the latter is frequently called ſtone, and it is the moſt common and moſt in uſe in the manufactories of glaſs.

10. Citizen Lapeyrouſe diſcovered and deſcribed, in the year 1786, native manganeſe in metallic globules at Sem, in the iron-ores of the valley of Vicdeſos, in the [ci-devant] comté de Foix. He is the only naturaliſt who has found this metal in the native ſtate. It was in the form of ſmall buttons a little flattened, malleable, of a lamellated texture: it is very probable, that this was only an alloy with iron; for manganeſe is too combuſtible to be capable of remaining without alteration in the metallic form.

11. It is neceſſary to add, that the oxide of manganeſe is found very frequently with other mineralized ſubſtances, eſpecially in the ores of iron, that Scheele has found it in a great number of charcoals and vegetable aſhes, and that

he attributes to it the green and red colours, which the fixed alkali that proceeds from theſe aſhes ſo often aſſumes. We ſhall have occaſion to ſpeak again of this phenomenon in another place. Hielm has found the muriate of manganeſe diſſolved in waters near the lake Wettern; and Citizen Guyton aſſures us, that carbonate of manganeſe exiſts in the water of the coaſt of Châtillon in Bugey.

D. *Aſſays and Metallurgy.*

12. THE native oxide of manganeſe is not well reduced, except when we avoid heating it with fluxes, and this is undoubtedly the reaſon why the chemiſts have remained ſo long ignorant of the exiſtence of the particular metal which is contained in it. Gahn firſt ſucceeded in obtaining it, only becauſe he employed no flux; in however ſmall a quantity we may add theſe, the oxide becomes vitrified: this fact has ſince been well confirmed by Bergmann, by Citizens Guyton and Champy, and by my own experiments. According to theſe principles, the following is the proceſs of Bergmann, which ſucceeds well.

13. We form a paſte of native oxide of manganeſe finely pulverized, and water; of this we form a ball, which we place in a lined crucible, upon the bottom of which is beaten a thick layer of powdered charcoal; we ſurround and cover the ball with charcoal; and cloſe with another

other crucible inverted and luted; and then heat with the moſt violent fire that can be made in a laboratory for upwards of an hour. It is neceſſary that the temperature of the furnace ſhould amount at leaſt to 160 degrees of Wedgwood's pyrometer. After the crucible has cooled, we find below, or even in the middle of a ſcoria, more or leſs vitrified, one or more metallic globules, which amount to near a third part of the quantity of the oxide of manganeſe that has been employed; Bergmann makes them amount to 0,30. If the fire be not ſufficiently ſtrong, the grains of metal being too ſmall and diſſeminated in the ſcoria, cannot unite. It is alſo obſerved, that when the crucible is overheated, and the metal touches its ſides, the whole maſs is vitrified, and no metal is obtained. I have ſeveral times attempted this difficult reduction: I have never had a ſufficiently ſtrong fire in my laboratories to collect the manganeſe in a ſingle button; but I have obtained it in grains or ſmall globules, each of which were ſurrounded with a vitreous cruſt of a deep green colour.

14. Bergmann, in his Diſſertation on humid Aſſaying, gives as docimaſtic proceſſes for the ores of manganeſe, the ſolution in nitric acid, with the addition of ſugar, evaporation to dryneſs of the nitrate which is thus obtained from them, and treatment of the mixed oxides of manganeſe and of iron, by the acetous, or the very weak nitric acid, which diſſolve the firſt, without attacking the ſecond by

the addition of the ſugar. He obſerves alſo, that when a ſolution of manganeſe and of iron is precipitated by the alkaline pruſſiates, the precipitate of pruſſiate of manganeſe is ſoluble in water, whilſt that of iron is not, and that this property furniſhes a very good means for ſeparating theſe two metals. It was by this means that Citizen Guyton diſcovered the preſence of carbonate of manganeſe in the water of Chatillon; but he remarks, that there is at the ſame time a ſmall quantity of pruſſiate of iron diſſolved in it.

15. The ores of manganeſe are not worked in the large way, not merely on account of the refractory nature of theſe ores, but more eſpecially becauſe it is of no utility in its metallic ſtate. The places where the native oxide of manganeſe is found, are merely worked, in order to furniſh the manufactories of glaſs, &c. with this oxide which is employed in them.

E. *Treatment by Fire and Air.*

16. It muſt have appeared from the preceding details, that as the oxide of manganeſe exiſts in great abundance in the bowels of the earth, whilſt the metal, on the contrary, is very difficult to be obtained, the oxide only muſt have been employed in the arts. As it is alſo upon this ſubſtance that all the experiments and diſcoveries of Scheele have been made, who did not know the metal, there is no other method whereby

we can well underſtand and comprehend the whole, than to compare, in the expoſition of each mode of treatment and phenomenon, the properties of this metal and thoſe of the oxide, or rather of the oxides; for it will frequently be neceſſary to deſcribe, in particular the effects of that which is at the *maximum*, and that which is at the *minimum* of oxidation.

17. There is no metal equally combuſtible, and which combines with oxigen more eaſily as well as more ſpeedily, than mangaueſe. Bergmann had remarked, that its colour was very ſubject to alteration by the air, and that it was ſometimes reſolved into a brown powder approaching to a black, which weighed more than the entire metal; he was ſtill ignorant of the cauſe of this phenomenon, which he attributed in a vague manner to the little approximation of the particles; moiſture had appeared to him to favour it, as well as the impreſſion of the atmoſpherical air; for he had obſerved, that a ſmall fragment of this metal, incloſed in a dry well-corked bottle, remained entire for the ſpace of ſix months, but that having been afterwards expoſed to the free air for twice twenty-four hours, its ſurface was tarniſhed, and it had become friable under the finger; finally he obſerved, that the parts moſt charged with iron reſiſted this ſpontaneous alteration much better. This is, undoubtedly, the caſe with the buttons that were kept expoſed to the air for ſeveral years without alteration by Citizen Guyton,

though, they were, however, not ſenſibly magnetic. The following is what I have aſcertained relative to the ſpontaneous oxidability of manganeſe. On breaking the ſmall globules, which I had obtained by the reduction of the native oxide without flux, I perceived that their freſh ſurface, from the brilliant greyiſh white which it exhibited at the moment when it was firſt expoſed, became almoſt inſtantaneouſly tarniſhed in the air, and ſoon aſſumed a lilac colour, afterwards a violet, which quickly paſſed into a black. In the latter ſtate, they were friable under the finger, and formed a black powder ſimilar to the native oxides. Having incloſed ſome of theſe globules entire, and covered with the ſmall layer of oxide formed or left during their fuſion, in a ſmall bottle well-corked, they remained there entire; but having broken them, in order to obſerve their grain and internal texture, and having placed them again in the ſame bottle, which was agitated from time to time in order to obſerve them, they were found at the end of ſome months entirely reduced to a black powder, which was more ponderous than the globules had been.

18. It cannot be doubted that this phenomenon depends upon the quick and eaſy abſorption of the atmoſpheric oxigen by the manganeſe; but it is very remarkable, that this is the only metal which preſents ſo rapid and violent an abſorption. This celerity of combuſtion,

which is not ſurpaſſed by any of the combuſtible ſubſtances except phoſphorus, is united with the powerful attraction which this metal exerts upon oxigen. We ſhall ſee hereafter that it takes it away from iron and zinc, and that it ranks above all other metals with reſpect to this property: accordingly Citizen Guyton has placed it in the firſt rank of oxidability; but it is not evident with what reaſon he places in the ſame line, iron, zinc, cobalt, and nickel, as theſe metals are far from exerting upon oxigen an equally ſtrong and active attraction. This is incontrovertibly proved by one of the experiments of Bergmann. Having ſtrongly heated, for the ſpace of twenty minutes, with the acid of ſulphur, ſome pieces of manganeſe incloſed in a covered Heſſian crucible, in which, however, there was a ſufficient quantity of air to effect its oxidation, he obtained an opaque yellow glaſs, and a ſmall globule of iron; conſequently the manganeſe was oxidated and vitrified in a place and temperature in which the iron reſiſted and was merely fuſed. This remarkable oxidability of manganeſe has induced me to think that it might be employed as an eudiometer, and that in order to preſerve it, it ought to be kept under oil, as water is not adequate for this purpoſe.

19. It is natural to expect that manganeſe muſt be ſtill more altered and burn with rapidity when heated in contact with the air. We ſee it paſs ſucceſſively through the grey, yellow, red,

brown, and black colours, in proportion as it abſorbs larger quantities of oxigen. Bergmann ſays, that the artificial oxide, heated for twelve days, without interruption, paſſes to an opaque green colour. I have no doubt, that at a high temperature, to which it ſhould be raiſed with rapidity and without having ſuffered it to ſaturate itſelf with oxigen, for example, when heated to redneſs in a well-cloſed apparatus, and ſuddenly plunged into vital air, at the moment when it would be ready for fuſion, it would become inflamed in as lively a manner as iron and phoſphorus, and throw out burning and very luminous ſparks to a conſiderable diſtance, though the experiment has not yet been made. The proportions of oxigen have not yet been determined, which it contains in its different ſtates of oxidation, from the grey-white, its evident *minimum*, to the deep black, its certain *maximum* of oxidation. Bergmann aſſerts, that manganeſe that had effloreſced in the air, and been converted into an obſcure (brown) oxide, during fourteen days, was augmented by 0,35. It is known, that at the ultimate term of oxidation, an hundred parts of manganeſe are increaſed in weight to 168.

20. The native or artificial oxides of manganeſe comport themſelves differently, when we expoſe them to the light and the action of caloric, according to their ſtate of oxidation. Thoſe which are the moſt oxided and the blackeſt, to which thoſe which are brilliant and

metalli-

metalli-form in nature ſometimes approach, when diſtilled, or rather heated, in cloſe veſſels, with the pneumelio-chemical apparatus, yield large quantities of conſiderably pure oxigen; leſs is obtained from the clear brown, the yellow, and the grey, and none at all from the white oxides. This fact, which is well atteſted, proves that the different portions of oxigen contained in the moſt complete oxide of manganeſe, adhere to the metal with a different force, and that we may ſeparate from it more or leſs eaſily the portion which blackens it, and in general colours it beyond the white, and that that which is combined with it in the laſt-mentioned ſtate of colouration, adheres to it with ſuch energy, that the action of the fire is incapable of ſeparating it without the intervention of a ſubſtance which joins to it its own particular attraction, ſuch as charcoal.

21. This property of the coloured oxides of manganeſe, of affording oxigen gas by the action of caloric, is frequently made uſe of in the chemical laboratories for procuring this ſpecies of elaſtic fluid. It has, however, been obſerved, that this gas is not ſo pure as that which is extracted from the ſpontaneous oxide of mercury, and eſpecially as that which is afforded by the ſuper-oxigenated muriate of potaſh. Sometimes it contains a ſmall quantity of carbonic acid gas; ſometimes alſo we find in it a ſmall portion of azotic gas, and it is undoubtedly to the preſence of the latter ſubſtance, that

we are to attribute the ſingular fact, obſerved long ſince by Bergmann, of ſome nitrous drops or vapours diſengaged during the treatment of the oxide of menganeſe, in a diſtilling apparatus. It is therefore evident, that for accurate experiments, the gas diſengaged from the ſuperoxigenated muriate of pot-aſh is to be preferred.

22. In proportion as the oxigen is ſeparated in the form of gas from an oxide of manganeſe coloured by the action of fire, it loſes its colour, and always paſſes towards the grey or white, which as we have already ſeen, approaches to the metallic ſtate: when this oxide, in part diſoxided, is expoſed to the contact of the air, it abſorbs atmoſpherical oxigen, blackens, and becomes capable of yielding a new quantity of gas by the action of caloric. I have repeated this experiment three ſucceſſive times upon the ſame oxide of manganeſe, and have thereby convinced myſelf that this oxide, deprived of the portion of the oxidating principle, which is diſengaged from it by the action of caloric, is a ſpecies of load-ſtone *(aimant)* for the atmoſpherical oxigen, by the aid of which we may procure this gas, almoſt without any other coſt than that of the combuſtibles requiſite for diſengaging it; but this gas is not ſufficiently pure for delicate experiments.

23. To theſe properties of the oxide of manganeſe dependent upon caloric, there is alſo to be added that of vitrifying alone when acted

upon by a ſtrong heat, and of yielding a greeniſh glaſs when heated in a veſſel which contains air, and which does not ſuffer the oxigen belonging to the metal to be diſengaged in the ſtate of gas.

F. *Treatment with combuſtible Bodies.*

24. No combination is known of manganeſe with azote, hidrogen, and carbon. It is known, that the latter, heated ſtrongly with the oxide of this metal, takes from it its oxigen, and reduces it if at a very high temperature: it appears, that it does not unite in this caſe with the metal, but with the iron which is alloyed with it, as will be ſhown hereafter.

25. Bergmann ſays, that metallic manganeſe appears to reſiſt combination with ſulphur, which I do not yet conſider as certain; but he deſcribes the combination which he formed between ſulphur and the oxide of manganeſe. Eight parts of this oxide united with three parts of ſulphur, in a glaſs retort, and produced a greeniſh yellow maſs, ſuſceptible of being attacked with efferveſcence, and yielding ſulphurated hidrogen gas by the acids. Scheele has alſo obſerved that part of the ſulphur paſſed to the ſtate of ſulphureous acid in this operation.

26. Pelletier has ſpoken of the combination of manganeſe with phoſphorus. Having heated equal parts of phoſphoric glaſs and manganeſe

with a quantity of charcoal, equal to an eighth of the former, he obtained a phoſphuret of a white, brilliant, and metallic colour, of a granulated texture, much diſpoſed, as he ſays, to cryſtallization, brittle, and which remains in the air without effloreſcence. He obſerves, that the manganeſe which he employed was not efflореſcent in the air. It is known, that this property depends upon its being alloyed with iron. Above the phoſphuret of manganeſe, there was an opaque glaſs of a yellowiſh colour. He effected the ſame combination by throwing phoſphorus upon manganeſe heated to redneſs in a crucible. This latter experiment having been made with efflореſcent manganeſe, Pelletier obſerves, that the phoſphuret, which was obtained, does not poſſeſs that character. This phoſphuret ſeemed to him to be more fuſible than manganeſe: when it is fuſed with the blow-pipe, the phoſphorus is ſeen to burn in proportion as the metal is oxided.

27. Manganeſe fuſes and forms alloys with moſt of the metallic ſubſtances; however, its alloys have hitherto been but little examined, eſpecially thoſe formed with the metals that have already been deſcribed.

G. *Action upon Water and the Oxides.*

28. THOUGH the labours of Bergmann and Scheele upon manganeſe and its oxide have not been reſumed ſince the diſcovery of the decom-

poſition of water, and though experience has not yet decided upon the reciprocal effects of this metal and that liquid, yet the celerity with which the metal unites with oxigen, and the attraction which it appears to have for the firſt portion, which converts it into white oxide, renders it probable to me, that it is, like iron and zinc, and perhaps even ſtill more than theſe two metals, capable of decompoſing water, and depriving it of its oxigen. We ſhall ſoon learn ſome facts, which appear to prove it in a ſufficiently demonſtrative manner; and it is on this account that I have adviſed not to keep it under water.

29. Its ſtrong attraction for oxigen indicates, that it is capable of taking this principle from moſt of the metallic oxides, and this is in fact what happens when we plunge it into ſolutions of theſe oxides by the acids; but it is neceſſary we ſhould attend to the different attractions which it has for various proportions of this principle, and to be well aware, that in heating its black oxide, or that which is moſt oxidated, with certain metallic ſubſtances, it may relinquiſh to them the part of its oxigen to which it adheres the leaſt, and thus contradict in appearance the general diſoxidating property, which ought to conſtitute its ſpecific character. This variety of attraction for different proportions of oxigen produces much variation in its properties, and gives riſe, as I ſhall ſhow hereafter, to a number of phenomena, which ſometimes ſeem to be contradictory to each other.

H. *Treat-*

H. *Treatment by the Acids.*

30. It is in this reciprocal action of manganeſe and its oxides, that the moſt ſingular facts in its hiſtory, and the moſt numerous phenomena of its combinations conſiſt. It is upon this action that Scheele and Bergmann have moſtly inſiſted. Whilſt it ſerved them to ſupport the ſingular theory which they had already adopted concerning heat, as compoſed of air and *phlogiſton*, it furniſhed the pneumatic doctrine with the moſt happy reſults for its proofs, and the moſt ſubſtantial ſupport for its confirmation, as I ſhall ſhow in the details upon which I am about to enter, as well from the experiments of the two illuſtrious Swediſh chemiſts, and thoſe which are peculiar to myſelf.

31. The concentrated ſulphuric acid acts even in the cold upon manganeſe; its action is much more prompt and ſtronger when it is diluted with two or three parts water. Whilſt it takes place, a remarkable quantity of hidrogen gas is diſengaged; but its ſolution is much ſlower than that of iron. There remains in the liquor a black ſpongy maſs, which retains the form of the metal, and which, as Mr. Kirwan has ſhown, is carburet of iron, a proof of which I have advanced (No. 24), that carbon, in the reduction of the manganeſe, combines with the iron. Its neutral ſolution is white and colourleſs; it affords

by evaporation tranſparent cryſtals, which are alſo colourleſs, in the form of parallelopipedons, of a very bitter taſte, which fire decompoſes, diſengaging from them ſulphuric acid and oxigen gas, and from which the fixed alkalis ſeparate a white oxide which quickly becomes brown when expoſed to the air, beginning at the uppermoſt layer in the veſſel in which the precipitation has been made; but the alkaline carbonates precipitate from it a carbonate of manganeſe which does not abſorb the atmoſpheric oxigen, nor become black like the preceding. In this action of the ſulphuric acid we ſee the decompoſition of water, and the fixation of a certain proportion of its oxigen which does not amount to more than 0,20, in the manganeſe, the white oxide of which is diſſolved in proportion as it is formed in the ſulphuric acid. The white oxide of manganeſe, ſeparated by the pure alkalis, diſſolves in all the acids when it is not yet become black, and at the moment when it has been precipitated, without having been expoſed to the air, and without having abſorbed oxigen, which renders it inſoluble. It is on account of this ſolubility that the white oxide quickly diſappears in the ſulphuric acid, even though it be diluted; and as it contains exactly the quantity of oxigen requiſite for its ſolution in this acid, it combines with it, without requiring to abſorb any from it, and conſequently without effervescence. For this effect takes place during the combination of the metallic manganeſe, only becauſe it abſorbs the oxigen of the water, from which it at the ſame time diſengages the hydrogen.

32. The black oxide of manganeſe is diſſolved with difficulty, by degrees, and in ſmall quantity, in boiling ſulphuric acid; however, the ſaturation of the ſolution is at length effected; and we find the cauſe of both theſe effects, on the one hand in the ſlowneſs of the ſolution, and on the other in the ſaturation which is effected. When we perform the operation in a cloſe apparatus provided with a pneumatic apparatus, we obtain oxigen gas, which manifeſtly proceeds from the oxide of manganeſe, which being thus diſoxidated, becomes ſoluble in the ſulphuric acid. If we diſtil to dryneſs, and waſh the reſidue, this fluid takes up ſulphate of manganeſe; and when the ſame operation is repeated ſeveral ſucceſſive times, the whole of the oxide of manganeſe is taken up. It is very evident in this caſe that the ſulphuric acid, by its attraction for the oxide, taken at its *minimum*, or in its white ſtate, is the cauſe of the diſengagement of oxigen, ſince this diſengagement is rendered much more ſpeedy by this addition of acid than it is in the diſtillation of the oxide alone, as is well known by all chemiſts who have occaſion to procure this gas. Another fact, which we owe to Scheele, equally proves the influence of the hot ſulphuric acid in the diſoxidation of manganeſe; namely, that if we add ſugar, honey, or

gum to the mixture of ſulphuric acid and this oxide, we render the latter ſoluble without its diſengaging oxigen in the form of gas, ſince it is abſorbed by the vegetable matter; an abſorption which does not take place without the preſence of the acid, for it is in vain to mix the oxide with the vegetable ſubſtances alone, they do not in any manner affect the oxidation. In the caſe of this addition, we ſee why the ſolution in the acid is more prompt than when it acts alone. In fact, there are here two forces which conſpire together, that of the acid upon the diſoxidable oxide, and that of the vegetable matters upon its oxigen: ſome metals, even gold, according to Bergmann, act by the ſame principle, and favour the ſolution of the black oxide in ſulphuric acid.

33. When, in the combination of the black oxide of manganeſe with ſulphuric acid, which I have juſt deſcribed, we diſtil to dryneſs this acid ſlightly diluted upon half its weight of oxide, we extract more than a fourth of the oxide, diſſolved in ſulphate, by means of water; and the ſolution is red or violet, as well as the cryſtallized ſalt which is obtained from it; which ſhows that in this caſe the oxide of manganeſe retains more oxigen than when the ſolution is white, as it is when the metal itſelf is made to act upon the acid; it is alſo to be concluded from hence, that there are two ſulphates of manganeſe, the one little oxidated, which is the white; the other at the maximum of oxidation in which the acid

can ſuſpend this oxide. We ſhall ſee that the caſe is the ſame with iron, which alſo affords two different ſulphates, according to the ſtate of oxidation of the metal. We quickly obtain the red or violet ſulphate of manganeſe, and particularly the latter, by uniting with the ſulphuric acid the oxide of this metal formed by its expoſure to the air, an oxide which eaſily diſſolves in it. The alkalis precipitate it in a reddiſh ſtate, and this precipitate blackens very quickly in the air. Bergmann obſerves, on this occaſion, that the red oxide of manganeſe holds in this reſpect the middle rank between the black and the white, that it is more ſoluble in the ſulphuric acid than the firſt, and leſs ſo than the white; we muſt add, that it forms with it an oxigenated or coloured ſulphate, whilſt the white affords a ſimple and colourleſs ſulphate. Vegetable ſubſtances that poſſeſs avidity for oxigen, deſtroy the colour of the oxigenated ſulphate of manganeſe, decompoſe it, and cauſe it to paſs into the white ſtate or that of ſimple ſulphate. It appears, according to ſeveral obſervations of Scheele, that organic bodies in thus diſoxidating the manganeſe, and favouring its ſolution in the acids, operate by means of their carbon, ſince he has remarked that carbonic acid was diſengaged.

34. The ſulphureous acid acts but feebly, or not at all, upon manganeſe, though it exerts a conſiderable action upon its oxide. Scheele had obſerved, that on receiving ſulphureous acid into

water, in which black oxide of manganeſe has been infuſed, this grows white, diſappears, and is gradually diſſolved in this liquid acid, without either motion or formation of bubbles. Moreover, he had remarked that this ſolution was of the ſulphate, not of the ſulphite of manganeſe, and that this ſulphate was white. Nothing can be more clear than this phenomenon in the pneumatic doctrine. The ſulphureous acid, having great avidity for oxigen, takes it away from the highly oxidated oxide, and returns to the ſtate of ſulphuric acid, which ſpeedily diſſolves the oxide, deprived of the portion of oxigen which was the cauſe of its inſolubility. Hence it is evident that no efferveſcence can take place, and that the ſolution muſt contain white and ſimple ſulphate of manganeſe. All theſe details will ſerve to place the action of the other acids upon manganeſe and its oxides in a clearer and more ſimple point of view.

35. Nitric acid diſſolves manganeſe with efferveſcence and diſengagement of nitrous gas; there remains behind a ſpongy, black, and light maſs of carburet of iron, which is not ſoluble. This ſolution is coloured on account of the iron which it contains; its colour is dark, and there is no red or violet nitrate of manganeſe, as there is ſulphate. The white or leaſt oxidated oxide of manganeſe diſſolves very eaſily in the nitric acid, and without efferveſcence as well as without diſengagement of nitrous gas: this is owing to the circumſtance, that

the oxide containing the portion of oxigen which it can hold in order to remain united with the acids, does not require to take any from the nitric, and conſequently to decompoſe this acid as its metal does. This nitric ſolution of the white oxide is colourleſs, as long as it contains no iron; it affords no cryſtallized nitrate of manganeſe, not even by ſlow evaporation. The black oxide diſſolves only in very ſmall quantity, and with great difficulty in the nitric acid, but it may be ſaturated with it in courſe of time. It is evident that this difference between the nitric and ſulphuric acids depends upon its being more volatile, its not having ſo great an attraction in general for the metallic oxides, its always tending more to yield oxigen to them, than to deprive them of it: the addition of ſugars of honey, of oils, and even of metals, to the mixture of the black oxide of manganeſe and the nitric acid, favours their combination; and the oxide, deprived of a portion of its oxigen by theſe bodies, whoſe tendency to unite with it is increaſed by the acid, diſſolves in this acid. Carbonic acid gas is diſengaged in this operation, and more even than in that which is performed with the other acids.

36. The nitrous acid diſſolves the oxide of manganeſe much better than the nitric. Scheele has ſeen and well deſcribed the important phenomena of this ſolution: it takes place without efferveſcence. Nitrate, not nitrite, of manganeſe is formed; the ſulphuric acid afterwards

diſengages white, not red vapours from it. This manifeſtly proceeds from the abſorption of the oxigen by the nitrous oxide, as is proved both by the ſolution of the oxide, which cannot take place without its previous diſoxidation, and by the converſion of the nitrous into nitric acid. It is ſuperfluous to remark in this place, how well all theſe facts accord with the pneumatic doctrine, and give ſtability to the principles which conſtitute it.

37. Manganeſe diſſolves with efferveſcence, and diſengagement of hidrogen gas in the liquid muriatic acid. Its white oxide unites with it alſo, but without efferveſcence or ſeparation of gas, as it does not require any abſorption of oxigen, with which it is ſufficiently provided to diſſolve in this acid. Its black oxide alſo diſſolves in it more eaſy than in the preceding acids, on account of the two-fold tendency which this acid exerts, on the one hand upon the oxigen with which it in part becomes ſaturated, in order to paſs into the ſtate of oxigenated muriatic acid; and on the other, upon the oxide of manganeſe, at the *minimum* of oxidation, with which it forms a ſalt. When we cauſe the muriatic acid to act upon the black oxide of manganeſe, there are two remarkable actions of this acid, and it divides its energy into two forces which form an equilibrium between themſelves, or rather which do not ceaſe to act till they are in equilibrio: the one diſoxidates the manganeſe, and forms oxigenated muriatic acid

till it has become ſoluble; the other diſſolves it and cauſes a portion of the acid to enter into a ſaline combination. This experiment led Scheele to the diſcovery of the acid which he termed *dephlogiſticated marine acid,* and the French chemiſts to the knowledge of the real nature of this compound, which they have denominated by the exact appellation of *oxigenated muriatic acid.* In the action of the muriatic acid upon the black oxide of mangaueſe, we obſerve the paſſage of this oxide to the red, the grey, and the white. In the laſt-mentioned ſtate, it unites with the acid and forms a colourleſs ſalt; if we add a combuſtible body, the ſolution of the black oxide in this acid is effected without the formation of oxigenated muriatic acid. The properties of the muriate of mangaueſe have not yet been deſcribed with accuracy. Bergman ſays that it affords cryſtals with difficulty, but only forms a deliqueſcent ſaline maſs. However, it frequently happens in the laboratories, that large cryſtals of this ſalt are obtained, the form of which has not indeed been yet determined. The muriatic acid decompoſes the ſulphate of manganeſe.

38. The oxigenated muriatic acid oxidates manganeſe to the white ſtate, quickly and without efferveſcence; it burns and inflames this metal when it is thrown in the form of powder or filings, into oxigenated muriatic acid. It alſo unites with the oxides of manganeſe, and forms ſolutions of the brown, red, or violet

colours, which afford cryſtals of the ſame tints. There is, therefore, an oxigenated muriate of manganeſe, the properties of which have not yet been diſcovered, and which it would be very important to examine.

39. The phoſphoric acid does not unite immediately with manganeſe; it diſſolves its oxides with difficulty: we may unite it with it by pouring a ſolution of an alkaline phoſphate into that of the nitrate or muriate of manganeſe; we obtain a precipitate of phoſphate of this metal. The caſe is the ſame with the fluoric acid, which alſo forms a fluate of manganeſe of little ſolubility. The ſame is done with the borates.

40. Liquid carbonic acid attacks manganeſe as well as its black oxide; both are diſſolved in it, though in ſmall quantity. This ſolution, expoſed to the air, gradually precipitates the oxides which ſeparate at the ſurface in a white pellicle, if no oxide of iron be preſent. Bergman obſerves, that when we uſe the metal in this combination, an odour analogous to that of burned fat is diſengaged.

41. We are not acquainted with the action of the four metallic acids upon manganeſe and its oxides, nor their combinations with this metal. We know, however, that the arſenious acid poſſeſſes the property of taking a portion of oxigen from the black oxide of manganeſe, and of paſſing in this manner into the ſtate of arſenic acid, and that it whitens it at the ſame time.

42. In general, none of the ſolutions of manganeſe in the acids is decompoſed, or rendered turbid by the contact of the air. The acids retain this oxide too ſtrongly for it to abſorb the atmoſpherical oxigen. The pure alkalis, and the alkaline earths, ſeparate the oxide of manganeſe from them in a brown ſtate, which quickly becomes darker coloured in the air, and by the mere contact of water containing air.

I. *Treatment by the Salifiable Baſes, and the Salts.*

43. No action is exerted upon manganeſe by the earths; its oxide combines and vitrifies with them, imparting different colours to them, according as this oxide contains more or leſs oxigen, and is more or leſs charged with iron. In general, theſe vitreous cruſts, or frits, are of the green, dark brown, blackiſh, or yellowiſh green colours; they are ſeldom red, unleſs we add to them ſome flux properly ſo called.

44. The pure alkalis promote the oxidation of manganeſe, and the decompoſition of water by this metal, as they eaſily unite with the oxide. Scheele has well deſcribed the union of the fixed alkalis with the oxide of manganeſe. In the dry way, theſe two ſubſtances are fuſed together into a dark green maſs, ſoluble in water, which it tinges green: when this ſolution is kept in a well-cloſed veſſel, a yellow oxide of

iron is precipitated from it, and the green liquor aſſumes the blue colour. Water precipitates the alkaline ſolution, giving it a violet, and afterwards a red colour. In proportion as the molecules of the oxide collect together, the liquid becomes white. The addition of ſome drops of acid, or expoſure to the air produce the ſame effect of precipitation, and the ſame caſts of colour, by oxidating the manganeſe in a leſſer degree. The arſenious acid, added to this alkaline ſolution, entirely deprives it of its colour, and renders it white by taking from it its oxigen. When we add carbon to the oxide of manganeſe and fuſe it with the alkali, there enſues an efferveſcence, diſengagement of carbonic acid, decoloration, or change of the colour into a greyiſh white. The carbonic acid is here formed by the combination of the carbon with the oxigen of the oxide, and this returns to the ſtate of white oxide. It is on account of theſe very remarkable changes of colour, as well as of the various caſts which the liquor treated in different ways aſſumes, that the name of *mineral chameleon* has been given to this combination. Theſe phenomena are found alſo in the crude alkalis of commerce, which contain a certain proportion of oxide of manganeſe, and aſſume a variety of different colours, accordingly as they attract the humidity, as they are expoſed to the air, as they are treated by the acids. Citizen Guyton thinks that in this combination, the manganeſe is in the acidified ſtate, and he terms it *manganeſic acid.*

45. Scheele was aware of the alteration which ammonia experiences by the action of the oxide of manganeſe, in the diſtillation of this oxide with the ammoniacal muriate; he has ſuſpected, that the ammonia was in part decompoſed, and to this decompoſition he attributed the ſpecies of gas which he had obtained, and which he carefully diſtinguiſhed from the carbonic acid. Citizen Berthollet has placed this truth out of doubt; he has ſhown, that when theſe two ſubſtances are diſtilled, the hidrogen, quitting the ammonia, ſeizes the oxigen of the oxide of manganeſe, with which it forms water, and that the azote, another principle of the volatile alkali, is diſengaged in a free ſtate. M. Milner has ſince made another diſcovery upon this reciprocal and decompoſing action: by cauſing ammoniacal gas to paſs through a tube filled with oxide of manganeſe heated to redneſs, he obtained nitrous gas by the combination of the azote of the ammonia with the oxigen of the oxide. This is one of the phenomena, which, as we have ſeen, confirm in the moſt powerful manner, the baſes of the pneumatic doctrine concerning the comparative nature of the nitric acid, ammonia, water, and metallic oxides. It is not improbable, that the oxide of manganeſe may hereafter become one of the moſt effectual means of the production

of the acid of nitre in the artificial manufactories of nitre.

46. Manganeſe and its oxides have no known action upon the ſulphates: theſe ſalts, however, poſſeſs the power of depriving glaſſes coloured by manganeſe of their colour, when aided by a ſtrong heat. The nitrates eaſily burn this metal, and ſtrongly oxidate it; it is on this account that fuſed nitre gives a violet or red colour to glaſſes whitened by this oxide, by reſtoring to it the oxigen which had been taken away from it in the fuſion of theſe glaſſes. The black oxides of manganeſe decompoſe the nitrate of pot-aſh in the heat, by diſengaging the acid, and combining with its baſe, with which they form a compound ſimilar to that which is formed immediately with the alkalis.

47. The phoſphates and the borates fuſed by the blow-pipe with the oxide of manganeſe, give colours which vary according to the ſtate of this oxide, and according to the kind of fuſion which they are made to undergo. Bergman and Scheele have given very accurate details concerning the phenomena of theſe combinations. A globule of phoſphate of ammonia fuſed by the blow-pipe, with black oxide of manganeſe, gives it a blue-red colour, or a red colour, if we add more of this oxide. By heating it upon charcoal, or adding to it a little of this ſubſtance in the ſtate of powder, its colour is diſſipated with efferveſcence: this is not effected except with the interior blue flame of

the blow-pipe; but if we employ only the white exterior flame, and the vitreous globule is thus expoſed to the air, the colour re-appears with the ſame tinge. Nitre cauſes it immediately to re-appear, whilſt ſulphur, the ſulphates, the metals, and many of the metallic oxides deſtroy it; the firſt of theſe ſubſtances yielding oxigen to the manganeſe, and the ſecond depriving it of this principle. When we have diſcoloured a ſaline vitreous globule charged with manganeſe by its diſoxidation, we may reſtore to it its former colours, by fuſing it again for ſome time in a veſſel of ſilver or platina, in contact with the air, which reſtores to it the oxigen of which it has been deprived. In the changes which take place ſo eaſily on a ſmall ſcale in experiment with the blow-pipe, we obſerve a very ſenſible difference, if we produce them or attempt to produce them in crucibles. Carbon and ſulphur act indeed as decolorant or diſoxidant ſubſtances, and the nitre as a colorant or oxidant; but the ſulphates and metallic oxides no longer produce the effects which they exhibit with the blow-pipe, ſince the contact of the air in one caſe, and of the combuſtible vapour of the blue flame in the other, act much more ſtrongly upon the globules than analogous ſubſtances are able to act in a crucible.

48. Borax produces theſe phenomena with ſome ſlight differences in the colours; inſtead of the reddiſh-blue given to the phoſphate, it is here of a yellowiſh-red; the ſaturation by the

oxide is indeed of a ruby-red in both caſes. Carbon effaces here the colour more ſlowly and with more difficulty than in the phoſphate, on account of the ſtronger adheſion which the oxide contracts with the borax.

49. Theſe beautiful phenomena of coloration, given to the fluxes by the oxide of manganeſe in different ſtates of oxidation, eaſily explain how this oxide clears glaſs. It is the oxide of iron which tends moſt commonly to colour the glaſs, and this oxide is not ſaturated with oxigen; when we add oxide of manganeſe, this laſt yields to the former all the oxigen which it wants in order to become colourleſs, and aſſumes the ſame caſt itſelf by loſing a portion of this principle. We ſee therefore why nitre reſtores the violet colour, by giving back the oxigen which it had loſt. Many other metallic oxides, and in general all the combuſtible ſubſtances which are able to take this principle from the black oxide of manganeſe, and which frequently form a part of the vitreous combination which they colour, are equally diſcoloured by this oxide. Moreover, it is evident, that it muſt be added in a quantity proportionate to that of the colouring ſubſtances combined with the glaſs: if we add too little, the primitive colour remains; if we add too much, the oxide, which is not entirely diſoxidated, colours with its own violet or reddiſh tinge, the glaſs that has an over-proportion of manganeſe.

K. *Uſes.*

50. It is eaſily conceivable from all that has been ſaid, that manganeſe and its oxide muſt be extremely uſeful inſtruments in chemiſtry; the firſt, as a metal which is extremely combuſtible, and abſorbs oxigen from many other ſubſtances in order to paſs into the ſtate of white oxide; the ſecond, in its black ſtate or at the *maximum* of oxidation, by introducing into ſubſtances an abundant and very active portion of the oxigen which it contains. Accordingly, beſides the oxigenated muriatic acid which this oxide forms, it may be employed in the analyſis of many bodies; and notwithſtanding the advanced ſtate of the ſcience, it may be confidently aſſerted, that the benefits which it has already derived from this beautiful metal, are nothing yet in compariſon with thoſe which it will derive from it hereafter.

51. The oxide of manganeſe is of great utility in the arts. Beſides its uſe in the glaſs manufactories for purifying glaſs, on which account it has been termed the glaſs-maker's ſoap, it is employed in enamels, porcelain, &c. It is of importance here to remark, that the accurate knowledge which we now poſſeſs relative to the nature, the differences, and the diſtinctive properties of this oxide, according to its different ſtates of oxidation, will, when

it ſhall have become more generally diffuſed, and when it ſhall have been introduced into the manufactories of glaſs, porcelain, and enamels, afford a much ſurer guide to the artiſts in their operations, than the blind routine and fallacious empiriciſm by which they have hitherto been directed. In a word, both for the arts and for ſcience, manganeſe is a ſubſtance, the ſtudy of which has already led, and will continue to lead, to the moſt uſeful and important reſults.

ARTICLE XI.

Biſmuth.

A. *Hiſtory.*

1. BISMUTH was known by the ancients, who gave it the name of tin-glaſs, which it has borne for a long time; amongſt mineralogiſts, and eſpecially ſince the appearance of the work of Agricola, when its differences, and thoſe of its ores from other metals began to be the ſubject of inquiry, it has been ſucceſſively named, according to the various and often erroneous notions which each author gave of it, *grey tin*, *grey lead* and *ſaturn*, *white antimony*, *white* and *ſilver-coloured marcaſite*, *jovial*, *grey pyrites*, &c. &c. It is mentioned by the name of *magneſia* in Geber, by that of *demogorgon* in

Glauber, of *nymph* in Van Helmont, of *glaure* in Augurellus.

2. Pott and Geoffroy the younger, in 1753, are the two firſt chemiſts who have ſtudied its properties, and diſtinguiſhed its ſpecific characters with accuracy. Darcet and Rouelle have ſubjected it to a courſe of remarkable experiments. Monnet, and Baumè, have afterwards deſcribed its principal combination in a more detailed and exact manner than their predeceſſors. Bergman has given a ſtill more accurate account of ſome of its combinations and its precipitates. The pneumatic doctrine has rendered its hiſtory much more exact and clear, though it has not yet been particularly occupied with the properties of this metal.

B. *Phyſical Properties.*

3. Pure biſmuth is a brittle metal, of a white colour, verging towards yellow, preſenting a texture of large brilliant and glittering plates. Its ſpecific weight is 9,822; it appears to vary, according to its greater or leſs degree of purity, between the limits of 9,822 and 10,000. As it is hollowed a little by the ſtrokes of the hammer before it breaks, and as it is not the moſt brittle of the metals of this order, Muſchenbroeck found, that fuſed biſmuth of 8,716, was brought by hammering to 9,638: notwithſtanding this approach of its plates, they break under a violent ſtroke;

they are reduced into a kind of ſmall filaments, and even into a fine powder which may be paſſed through a ſilk ſieve; in this ſtate it is of a dirty grey colour.

4. With a little caution in diſſecting it, we eaſily obtain a regular octahedron from a lamellated fragment of biſmuth. Citizen Guyton, gives it the third rank with reſpect to hardneſs, and places it next to copper with regard to this property. Its elaſticity is ſmall; it has a peculiar ſmell and taſte though they are ſlight and little perceptible; it eaſily conducts electricity and galvaniſm.

5. The dilatability of biſmuth has not yet been eſtimated. It fuſes very quickly and eaſily. Citizen Guyton ranks it with reſpect to this property between tin and lead, and determines its fuſibility at the 205th degree of Reaumur's thermometer. It may be poured in the fuſed ſtate into a cone of paper, without burning or even ſcorching it. If we ſuffer it to cool ſlowly after its fuſion, it cryſtallizes in parallelopipedons which join or rather meet at a right angle, and are enveloped in one another, like the turns of a volute, ſuch as are termed *à la Grecque*, becauſe the Greeks have often employed this form in their architecture. In order to obtain this cryſtallization, we muſt wait till the biſmuth is fixed at its ſurface, then perforate the cruſt, and pour off the fluid portion, not in order to leave a ſpace ſufficient for the regular arrangement of the molecules, as

Romè de Liſle imagined, for the cryſtals are formed in the midſt of the liquid metal, like the ſalts in their ſolution,—but in order to lay bare the cryſtals that are already formed, and not ſuffer them to be incloſed in the whole of the fixed metal. Citizen Pouget has actually obſerved, that when the ſolid cruſt formed at the ſurface of the fuſed biſmuth is taken away, whilſt the lower part is ſtill liquid, this cruſt exhibits well-formed cryſtals beneath. Of all the metals, this cryſtallizes in the moſt regular and eaſy manner: it is alſo the firſt metal which the chemiſts have cauſed to cryſtallize.

6. Biſmuth heated for a long time, and violently after its fuſion, ſublimes and riſes in vapour in well-cloſed veſſels. It attaches itſelf and cryſtallizes in ſmall brilliant filaments at the upper part of the apparatus, in which it is ſubjected to this high temperature. On account of this volatility, and at the ſame time of its brittleneſs, it was ranked amongſt the ſemi-metals: it was ſaid to be the heavieſt of the ſemi-metals, and it was compared, with reſpect to them, to lead with reſpect to the perfect metals.

C. *Natural Hiſtory.*

7. The ores of biſmuth are not very numerous. There are only three that have been well diſtinguiſhed from each other: the one is the native biſmuth; the ſecond is the ſulphuret

of biſmuth, and the third is an oxide of this metal. That which has been termed arſenical ore of biſmuth, is only an accidental mixture of biſmuth with arſenic.

8. Native biſmuth, which is very eaſily diſtinguiſhable by its colour, its brittleneſs, and its fuſibility, which enables it to flow, when the gangues which contain it are placed at a ſmall diſtance from the fire, or when the flame of a taper is applied to the fragments which then become every where covered with well-fuſed globules,—is ſtill more diſtinguiſhable by its appearance and its form. It is found in ſmall, yellowiſh, brilliant, triangular, or ſtriated laminæ, in dendrites engaged in the gangue, or in regular octahedrons of the ſame colour, which are often very well pronounced: it may be cut by the knife, and it breaks eaſily under the ſtroke of the hammer. It is frequently found at Scala in Neritia, in Dalecarlia, at Schneeberg, at Baſtnaës in Sweden. It is frequently mixed with arſenic interpoſed between its molecules.

9. The ſulphuret of biſmuth is an ore of a blackiſh-yellow colour, ſometimes of a yellowiſh tinge, or in irregular maſſes much reſembling thoſe of the ſulphuret of lead, or cryſtallized in pointed priſms, very like the ſulphuret of antimony. Its fracture is brilliant and lamellated. The longitudinal diviſions, as Citizen Haüy remarks, take place parallel to the ſides of an hexahedral priſm, and others are per-

ceived which are oblique to its baſes. The ſmallneſs of the fragments has not yet permitted him to aſcertain with accuracy the poſition of thoſe different ſections, and conſequently to determine the primitive form of this mineral. The ſulphuret of biſmuth is diſtinguiſhed from that of lead by its being fuſible by the flame of a taper. When it is heated by the action of the blow-pipe, the white vapour which exhales from it attaches itſelf to the charcoal in an incruſtation of a reddiſh-yellow colour, which becomes white by cooling. In this mineral the biſmuth is combined with the ſulphur in the metallic ſtate; ſometimes it appears that the biſmuth contains iron. It was undoubtedly this circumſtance that induced Cronſtedt to admit an ore of biſmuth and iron, mineralized by ſulphur, in large cuneiform ſcales at Konigſberg in Norway.

10. The *native oxide of biſmuth* : this which is frequently found with the native oxide of biſmuth, or at the ſurface of the ſulphuret of biſmuth, is alſo ſometimes inſulated and depoſited or diſſeminated upon ſtony gangues in granulated efferveſcences, of a greeniſh-yellow colour, very eaſily diſtinguiſhable by its caſt. Mr. Kirwan believes that this oxide is combined with the carbonic acid. Bergman ſays that it is of a whitiſh colour, and very ſcarce.

D. *Aſſay and Metallurgy.*

11. The aſſay of the ores of biſmuth is one of the moſt eaſy and ſimple; it conſiſts in mixing the ores, pounded and waſhed, with an eighth or a quarter of their weight of reducing flux, placing them in a lined crucible, well cloſed, and fuſing them with a gentle heat and rapidly, in order to prevent the volatilization of the metal. Cramer eſpecially recommends to perform this operation in well-cloſed veſſels. A button is obtained which is to be accurately weighed.

12. Bergman directs as a means for aſſaying ores of biſmuth, in the humid way, ſolution in the nitric acid: the ſolution is precipitated by means of water, as we ſhall ſee hereafter; and if the ore of biſmuth contain any foreign metals, theſe remain diſſolved after the precipitation of the former. The ſulphuret of biſmuth diſſolves alſo in the nitric acid, by the aid of a ſlight ebullition; the ſulphur ſeparates from it in proportion as the oxidated metal paſſes into the acid; it is then waſhed; and its purity is aſcertained by its burning without reſidue upon an ignited coal, and its quantity is determined by weight. The caſe is the ſame with the native oxide of biſmuth; the nitric acid diſſolves it; it is precipitated by water and iron, or cobalt: if the ore contains any, it remains in ſolution. Bergman aſſerts, that in precipitating the oxide of biſmuth, diſ-

ſolved by the nitric acid, an hundred and thirteen parts of the oxide that is ſeparated repreſent exactly one hundred parts of the metal taken away from the ore. The weight of the precipitate is equal to the diſſolved portion when we aſſay a native oxide.

13. The working in the large way, or the metallurgy of the ores of biſmuth, is not more difficult than the aſſay, on account of the eaſy reduction and fuſion of this metal. Generally, in the places where the ores of biſmuth abound, a pit of ſmall depth is dug in the ground near the place where the ores are extracted; this pit is covered with billets of wood placed near each other, which are kindled, and the ore broken into fragments thrown upon them. The biſmuth roaſts, becomes oxidated, paſſes through the coals, is reduced, fuſed, runs, and collects in a cavity beneath, where it forms an orbicular cake. In this manner are formed thoſe cakes of biſmuth, convex on one ſide and flat on the other, and frequently cryſtallized at the flat ſurface, which we ſee hung up in the ſhops of our druggiſts.

14. In other places they incline over an hole dug in the earth, the trunk of a fir-tree, ſplit in two and hollowed into a channel, upon which a bed of dry wood is laid and ſet on fire; the ore is thrown upon this fire; the metal runs along the channel in the trunk of the fir, into the hole or receptacle, where it collects, and whence it is taken out with iron ladles and

poured into moulds of iron, where it becomes fixed in ingots. We ſee by the ſhort account of this work, which is the moſt ſimple of any in metallurgy, that biſmuth cannot always be perfectly pure, and that it is not ſurprizing that we frequently find ſulphur in it, which is ſeparated during its ſolution.

E. *Oxidability by the Air.*

Biſmuth is but very ſlightly altered in the cold by the contact of the air; it only loſes its brilliancy and becomes covered with a ſlight duſt of a yellowiſh-grey colour; but it burns very eaſily, and quickly abſorbs the atmoſpheric oxigen when it is heated in contact with the air. Pott has obſerved, that by conſtantly agitating in the air, by means of the ſtalk of a tobacco-pipe, pulverized biſmuth expoſed to a very gentle fire, in a flat veſſel, it was reduced into an oxide of a yellowiſh-grey colour, eaſy to be vitrified and reduced by combuſtible ſubſtances. As it becomes vitrified after its oxidation, it penetrates the pores of the cupels; and ſome authors have propoſed to ſubſtitute it in the place of lead for cupellation, as being oxided and abſorbed quicker than the latter; but it has been obſerved that it flies about, and forms maſſes reſembling muſhrooms and cauliflowers, and that in this manner it might occaſion a loſs of the precious metals, as I ſhall ſhow upon another occaſion.

16. When we fuſe biſmuth in contact with

the air, it quickly becomes covered with a pellicle exhibiting the priſmatic colours, and by agitation, whilſt the application of the heat is continued, it is changed into a powder or oxide of a greeniſh grey and ſometimes of a brown colour, which has been termed aſhes of biſmuth. In this operation it increaſes by about a twelfth of its weight. If we continue to ſtir and heat it in the air, it aſſumes a yellow colour approaching to orange, and becomes a little heavier than it was before. Citizen Guyton reckons the augmentation of the weight of biſmuth completely oxidated, at 0,25, which appears to me to be too much. Geoffroy the younger has obſerved, that when fuſed biſmuth is heated to redneſs in an open crucible, it inflames with a ſlight exploſion, emits a blueiſh light, and at the ſame time riſes into the air in a yellowiſh ſmoke, condenſible into what was then improperly termed *flowers of biſmuth*, of the ſame colour. This oxide, which at laſt becomes very like *minium*, or the red oxide of lead, according to the ſame chemiſt, is not volatile, neither is it raiſed into vapour in the abovementioned operation, except by the deflagration which the inflamed biſmuth undergoes.

17. Citizen Darcet having expoſed biſmuth in bowls of the crude paſte of porcelain, to the fire of the oven in which this earth is baked, conſtantly obſerved this metal to run out through a crack in the crucible, the external part of which it coated with a yellowiſh glaſs, whilſt the oxidated and vitrified portion of the

metal in the inſide of the crucible was of a dirty violet colour. The oxide of biſmuth is therefore ſuſceptible of vitrifying by itſelf into a glaſs of a greeniſh-yellow colour. Citizen Guyton places it in the fifth rank of oxidability. However, this oxide, though it is not reduced by the mere action of the fire, eaſily returns to the metallic ſtate, and quickly yields its oxigen to many other combuſtible bodies.

F. *Union with the Combuſtible Subſtances.*

18. No combination is yet known between azote, hidrogen, carbon, and biſmuth. The two laſt of theſe combuſtibles exert by heat an action upon its oxides, and eaſily reduce them, by ſeizing their oxigen.

19. Very little attraction ſubſiſts between biſmuth and phoſphorus. Pelletier has endeavoured in vain to combine theſe two bodies, both by their immediate fuſion, by treating the biſmuth with vitreous phoſphoric acid and carbon, and by ſubſtituting the oxide in the place of the metal in the laſt-mentioned mixture: all his trials uniformly preſented a ſpeedy diſengagement of the phoſphorus, and the biſmuth was collected in a button without alteration, and almoſt without union with the phoſphorus, as he found no indication of the preſence of the latter, except a ſlight greeniſh flame which it exhaled when violently heated with the blowpipe. Its grain, its colour, and its other pro-

perties were not changed. He has calculated that the biſmuth did not retain more than 0,04, and his experiments prove that he has even overcharged the proportion. There exiſts, conſequently, no phoſphoret of biſmuth.

20. The caſe is not the ſame with ſulphur; it eaſily unites with biſmuth. When we heat equal quantities of theſe two metals in a crucible, we perceive that the fuſion of the metal is retarded, and that in order to fuſe it, much more heat muſt be employed than would be neceſſary if the metal were by itſelf. By the application of a ſtrong fire, we obtain a brilliant black or greyiſh-black ſulphuret, ſuſceptible of yielding, by well-managed refrigeration, beautiful cryſtalline needles, frequently tinged with the moſt brilliant deep blue and red colours, in priſms of four ſides very much elongated. This cryſtallization is effected by ſuffering the ſurface of the fuſed biſmuth to cool and become fixed, then piercing the ſolid cruſt which forms at its ſurface, and letting the portion which is ſtill liquid run off, whereby a kind of factitious geode or cavity is formed, lined with the moſt beautiful needles, and which when ſawed through longitudinally, preſents a cryſtalline maſs, worthy of being placed in valuable collections amongſt the moſt beautiful productions of art. This ſulphuret of biſmuth, which is much more difficult of fuſion than the biſmuth itſelf; which does not loſe its ſulphur except by long roaſting, and from which

the ſulphur is never completely ſeparated, except by the action of the nitric acid, greatly reſembles the ſulphuret of antimony, from which it may, however, be diſtinguiſhed by an attentive examination, as it does not ſoil the fingers like the latter, as it is a little leſs fuſible, and as the vapour which it yields before the blow-pipe, aſſumes a reddiſh tinge, whereas that of the ſulphuret of antimony remains white, as has already been mentioned in treating of the ores of biſmuth.

21. Sulphurated hidrogen gas colours the ſurface of biſmuth, and ſtrongly blackens the oxides of biſmuth, which it brings towards the metallic ſtate by reducing them to the ſtate of ſulphuret.

22. Biſmuth is eaſily alloyed with many metals; but it does not unite without difficulty with moſt of thoſe that we have already examined. In fact, its combination with tungſten, molybdena, chrome, titanium, and uranium are not known. That which it is capable of forming with arſenic, has alſo been hitherto ill deſcribed. Wallerius has remarked, that they cannot be united by fuſion; it is known that in ſmelting it, it ſeparates from cobalt, at the top of which it collects; that it, nevertheleſs, unites with this metal by the acid of nickel: its alloy with the latter affords, according to Cronſtedt, a brittle, ſcaly, micaceous metal. It does not appear to be ſuſceptible of uniting with mangaueſe.

G. *Action of Water and the Oxides.*

23. Biſmuth exerts no action upon water; its attraction for oxigen is too weak to take it from the hidrogen. On the contrary, we find that this latter principle takes the oxigen from the oxides of biſmuth, colours them, and cauſes them to return to the ſtate of biſmuth. It is true that hidrogen acts much more powerfully upon theſe oxides when it contains ſulphur, ſince this ſeizes the metal at the ſame time that the hidrogen attracts the oxigen of the oxide of biſmuth. From this double attraction proceeds the brown or green colour, which is imparted to the white oxide of biſmuth, in ſo rapid and ſenſible a manner, by the vapours of the hidroſulphurets, or the hidrogenated ſulphurets.

24. It is to be expected that a metal that has ſo little attraction for oxigen, or rather which has ſo ſlight an adheſion with this principle, will be able to take it from but very few metallic ſubſtances; accordingly biſmuth does not act ſenſibly upon the metallic oxides, if we except thoſe of the leaſt combuſtible metals, with which it eaſily divides the oxigen which they contain; as it appears to yield a part of its own to other oxides. This fact is exemplified in the manufacture of porcelain, and in the preparation of enamels, where the colours are often ſeen to be modified by the mixture of theſe different

oxides; modifications which are owing merely to the diſtributions of oxigen amongſt the different oxides which are mixed in the vitrifications.

H. *Action of the Acids.*

25. All the ſolutions of biſmuth in the acids, and even the cryſtallized ſalts which are obtained from them, reſemble each other, and differ from all or almoſt all the other metallic ſolutions, as well as from all their ſalts, in the circumſtance that the addition of a ſufficient quantity of water decompoſes them, and precipitates from them an oxide of biſmuth, of a more or leſs beautiful and brilliant white colour. This phenomenon ſhows that the biſmuth is ſtrongly oxidated by the action of the acids, that it has little adheſion with the ſolvents, and that it forms with them combinations of very little permanency; but it is very remarkable, that this metal ſhould exiſt in them more highly oxidated than it is by the ordinary proceſs of oxidation with the aid of fire and water, and that it ſhould have a white colour, whilſt the oxide, made in the ordinary manner, has only a dirty grey or yellowiſh caſt. This phenomenon is found to take place in ſeveral and even in almoſt all the metallic ſubſtances.

26. The concentrated ſulphuric acid exerts no action in the cold upon biſmuth; but this metal decompoſes the acid by ebullition; and

by means of diſtillation, ſulphureous acid gas is diſengaged; the biſmuth being oxidated and converted into a white powder. If we heat it ſtrongly, ſulphur is volatilized. When we waſh this maſs with water, the liquid takes up the remaining acid, and a ſmall quantity of oxide of biſmuth. The lixivium yields ſmall, needled, and ſoft cryſtals by a well-managed evaporation: this ſulphate of biſmuth is decompoſed by water, which ſeparates from it a white oxide. The portion of this oxide, that is ſeparated from the maſs by the firſt lixiviation, does not ſenſibly retain ſulphuric acid, and is reduced with much greater difficulty than the oxide formed by the action of fire and air.

27. The ſulphureous acid does not attack biſmuth; it unites with its oxide, and forms with it a white ſulphite inſoluble in water, and even in its acid, of a ſulphureous taſte, fuſible by the blow-pipe into a reddiſh-yellow maſs, which is reduced into metallic globules upon charcoal, decompoſable with effervefcence by the ſulphuric acid, yielding by diſtillation ſulphureous acid, and leaving alſo a white and pure oxide.

28. Nitric acid exerts a very lively action upon biſmuth. When this acid is a little concentrated, and the biſmuth in the ſtate of powder, the re-action between the bodies is ſo violent, and the effervefcence, the ſwelling, and the diſengagement of nitrous gas, as well as the formation of the red and thick nitrous vapour which

this gas produces in the air, are ſo rapid and active, that the whole of theſe phenomena preſent a ſtriking example of a combuſtion which requires nothing except flame to render it complete: in fact, it is a real and very violent combuſtion, and is attended with a great production of heat. The biſmuth is burned by the decompoſition of the acid into white oxide, which, after the action has ceaſed, if the quantity of acid requiſite for its oxidation have not been added, remains dry; ſometimes in this operation the metal becomes inflamed and throws out ſparks. If we take a weaker acid, no ſuch violent action enſues; the oxide, in proportion as it is formed, is diſſolved in the acid. It is obſerved, that a black inſoluble powder is detached from the metal, which Pott conſidered as an oxide of biſmuth, and which others have taken for ſulphur: it is not yet known whether it is not charcoal. The nitric ſolution prepared in this manner is colourleſs, and depoſits cryſtals frequently without evaporation. This ſalt has been deſcribed as having the form of tetrahedral priſms, compreſſed with obtuſe trihedral ſummits: I have obtained it in flat rhomboidal parallelopipedons, reſembling the Iceland cryſtal, but with much more obtuſe angles. The nitrate of biſmuth detonates feebly, and with ſmall reddiſh ſcintillations upon ignited charcoal; it fuſes, boils, ſwells, exhales nitrous vapour, and leaves a greeniſh-yellow oxide difficult to be reduced. It dries in a dry air, and in humid air it becomes a little moiſt and covered with a white and opaque pellicle As ſoon as it is brought into contact with water, it renders it turbid, decompoſes it, precipitates a white oxide, and affords only nitric acid with a very ſmall quantity of water. This decompoſition is effected with the nitric ſolution, which is poured gradually into a large quantity of water, in order to obtain the oxide, which was formerly termed *magiſtery of biſmuth*, and which is ſtill called pearl white in the ſhops, and is employed as a paint for the ſkin. If we wiſh to obtain this precipitate very white, and in a ſtate of extreme diviſion, in order that it may be very mild, it muſt be prepared with a large quantity of water, agitated for a long time, well waſhed, and dried with great precaution, and in places where there is no combuſtible vapour. Frequently it aſſumes a lamellated and brilliant form, like light mother of pearl, or the white ſcales of fiſhes. At leaſt 113 parts are obtained from 100 of biſmuth that have been employed; and as the water which diſſolves the acid retains alſo a certain quantity of oxide which is ſeparated by the addition of the alkalis, we muſt add a little more weight to the augmentation which this metal experiences in its oxidation by means of the acid; for Bergman reckons it only at 113 to the hundred, indicating only the oxide that is ſeparated by the water. The oxide of biſmuth obtained in this manner, when employed as a white paint for the ſkin, has the inconvenience of being very eaſily turned to a dark grey, brown, or even black colour, by the contact of ſulphurated or carbonated hidrogen gas, and even by that which is diſengaged from hot, hard-boiled eggs, from privies, ſewers, and from various boiled vegetables.

29. The muriatic acid acts with difficulty upon biſmuth; in order to favour its action, it is requiſite that it ſhould be concentrated, and kept for a long time in digeſtion, or even diſtilled upon this metal reduced to powder. During this action a fetid ſmell is diſengaged, which is probably owing to a particular hidrogen gas, though this has not yet been aſcertained by experiment, ſince the metal being decompoſed, as ſhall ſoon be ſhown, and the acid not being capable of being decompoſed, there is only the water that can ſupply it with oxigen; and the other principle, the hidrogen, muſt be exhaled at the ſametime. By evaporating the acid that has been heated upon the biſmuth, or by waſhing the maſs which remains after the ſlow diſtillation carried to dryneſs, and by evaporating this ſolution, we obtain, though with difficulty, ſlender needles of muriate of biſmuth in ſmall quantity; for the greater part of the oxide of biſmuth has been ſeparated by the water. The muriate is ſublimed by the action of the fire into a thick ſolid ſubſtance, fuſible by a gentle heat, which was formerly termed *butter of biſmuth*; it is deliqueſcent, decompoſable by water, which ſeparates from it a very fine white oxide.

30. The oxigenated muriatic acid oxidates biſmuth with much promptitute and activity, and forms, with the oxide which it produces, the ſame ſalt as the preceding. If we throw pulverized biſmuth into oxigenated muriatic acid gas, it becomes inflamed and throws out white ſparks at the moment when it comes into contact with this gas. The veſſel in which this experiment is made, is afterwards entirely covered with white oxide of biſmuth. The action of the oxigenated muriatic acid upon biſmuth is not known; it is not known whether theſe ſubſtances unite together, and whether there exiſt an oxigenated muriate of biſmuth, and in what reſpect it may differ from the ſimple muriate of this metal.

31. We are equally ignorant of the nature and properties of the combinations of the phoſphoric, fluoric, and boracic, as alſo of the metallic acids, with the oxide of biſmuth; the action of theſe acids upon the metal has not been appreciated. Its oxide, however, is combined with moſt of theſe acids, by pouring ſolutions of the alkaline ſalts which they form, into a ſolution of nitrate of biſmuth. In this experiment we obtain white precipitates; we know alſo that there exiſts a carbonate of biſmuth, for when we precipitate ſolutions of biſmuth in the acids by means of the alkaline carbonates, we do not ſee the carbonic acid diſengaged, at leaſt not entirely; and the precipitate obtained by

theſe ſalts weighs more than the oxide of the metal ought to weigh if it were pure.

32. All the ſolutions of biſmuth by the acids are precipitated by the alkaline earths, the alkalis, and the alkaline carbonates, in a white powder. Bergman ſays, that a hundred parts of biſmuth diſſolved, yield by ſoda 125 parts of precipitate; by the carbonate of ſoda, 130; by the pruſſiate of pot-aſh, 180. To all the facts that have already been indicated it muſt be added, that theſe ſolutions are never ſaturated, but always acid, though it ſeems that the oxide of biſmuth itſelf is in a ſtate approaching to acidity, eſpecially with reſpect to its ſlight adheſion with its ſolvents.

I. *Action upon the Saliſiable Bases and the Salts.*

33. The oxide of biſmuth unites by the vitreous fuſion with ſilex, to which it imparts a greeniſh-yellow tinge. The alkaline earths exert no ſenſible action upon this metal. Pott aſſures us that the fixed alkalis reduce biſmuth in ſcoria; but there is reaſon to believe that this ſcorification depended upon the air and the veſſels. Ammonia does not act upon biſmuth; it is however aſſerted, that it aſſumes a yellowiſh colour with it. Margraff ſays, that its oxide diſſolves well in this volatile alkali. The combination of the oxide of biſmuth with the alkalis, deſerves to be well examined by

chemiſts, as it promiſes combinations in which this oxide may act the part of an acid.

34. Biſmuth produces no alteration, either in the ſulphates or ſulphites; it is burned and oxidated by the nitrates. When ſtrongly heated and thrown into a red-hot crucible with nitrate of pot-aſh, it detonates feebly without any rapid or brilliant inflammation; it is reduced into an oxide, of which one portion combines with the pot-aſh. Pott aſſerts that biſmuth is oxidated, diſſolved, and ſublimed by muriate of ſoda.

This metal does not act upon the muriate of ammonia, but its oxide decompoſes it very well; even in the cold, it begins to diſengage from it a ſmall quantity of ammonia by ſimple trituration; and by heat it is totally decompoſed, and leaves a muriate of biſmuth which is ſublimed entirely when acted upon by a ſtrong fire. It here performs the functions of an alkali or a ſalifiable baſe.

The ſuperoxigenated muriate of pot-aſh burns biſmuth with a flame, and oxidates it completely and very quickly, by the aid of heat, or the contact of an inflamed body. A mixture of one part of this metal in fine powder, and three parts of the ſalt, fulminates with the emiſſion of ſparks, when ſtruck upon an anvil with a hammer.

The phoſphates and phoſphites, the borates, the fluates and the carbonates, do not act upon biſmuth. Theſe ſalts, which are frequently termed the vitreous flux, on account of their property of vitrifying with many ſubſtances, are actually fuſed into a glaſs with biſmuth, which gives them a yellow colour with more or leſs of a greeniſh caſt, according to its different ſtate of oxidation.

K. *Uſes.*

35. Biſmuth, which has been compared with lead, but very improperly, ſince it differs from this metal in moſt of its properties, and ſince ſome points of ſtrained analogy which Geoffroy the younger has found in it, are much fewer than the differing characters which it preſents, is very frequently employed in its metallic form. It is alloyed with ſeveral metals, in order to give them hardneſs, rigidity, or conſiſtence; it is particularly uſeful to the pewterers, and all thoſe who employ white and hard alloys. It is generally believed that it acts upon the animal economy in the ſame manner as lead, though this opinion is yet ſupported by no deciſive facts. In this ſtate of uncertainty, and eſpecially on account of the ſuſpicion which all well-inſtructed authors have entertained of biſmuth, it ought never to be employed internally except with much prudence and caution.

36. The utility of its oxides is very conſiderable. It is employed in this form by the manufacturers of porcelain in the preparation of ſome yellow enamels: it is mixed with other oxides,

in order to tinge the colours of glazes and paintings. It is ſometimes uſed in the manufacture of coloured glaſs, to give a yellow tinge approaching to green. The white paint or fucus is the moſt common preparation of this metal in the ſtate of oxide. Beſides the inconveniences which I have already mentioned, and which are not of ſufficient conſequence to prevent females from employing it, as the contact of the hidrogenated vapours may be avoided, a more important intereſt ought to diſſuade them from its uſe. The oxide of biſmuth injures the ſkin, either by obſtructing its pores, or by conſtricting and irritating its texture, or by thickening, hardening and blackening it: it is employed for rendering the hair black. The Germans uſe the white oxide of biſmuth, in doſes of half a grain, as an antiſpaſmodic and ſedative in ſpaſms of the ſtomach, eſpecially with female patients. Mr. Reil has given us ſome obſervations on this property of the oxide of biſmuth.

ARTICLE XII.

Concerning Antimony.

A. *Hiſtory.*

1. THOUGH there are ſome reaſons to believe that antimony was not entirely unknown to the ancients, but that they gave it another name

and employed it in ſome alloys; it is certain that its diſtinction as a particular metal, and the more profound inveſtigation of its properties, are to be attributed to Baſil Valentin, who flouriſhed towards the end of the fifteenth century. It was in a firſt work profeſſedly written upon the ſubject, and entitled *Currus Triumphalis Antimonii,* that he recorded many diſcoveries relative to this metallic ſubſtance, and eſpecially its ſulphuret; for it is to be obſerved that the name of antimony was given to the ſulphureous combination of this metal, which was well known before it was underſtood how to extract from it the metal itſelf. Kerkringius, in the ſeventeenth century, commented upon the treatiſe of Baſil Valentin; and his numerous notes contain, if not details, at leaſt the firſt baſes of all the diſcoveries that have ſince been made upon this ſubſtance.

2. No ſubſtance has been more ſtudied than this, none has been the ſubject of ſuch numerous labours, and there is none concerning which ſo much has been written. We might collect a library merely of the treatiſes that have been written upon this ſubject. The alchemiſts, who conſidered it as the ſubſtance the beſt adapted to the ſcope of their reſearches, have beſtowed immenſe labours upon this mineral, and, if I may uſe the expreſſion, have tormented it in every poſſible manner; in another point of view, it offered great motives for hope to the adepts, and many of them expected to find in it

the univerſal remedy. It would be difficult to enumerate the immenſe number of medicinal preparations that have been made with the ore and the metal that are to form the ſubject of this article. All perſons who occupied themſelves with chemiſtry, and the healing art, entertained for a long time exaggerated opinions relative to this ſubject. The one party could find nothing but excellent and powerful remedies in the antimonial preparations; the other conſidered them only as poiſons, and thought they ought to be baniſhed from medical practice. It was difficult to remain indifferent with reſpect to ſo important a ſubſtance, and hence aroſe the great number of experiments that were made, and the multitude of diſſertations that were written upon antimony.

3. Lemery was the firſt chemiſt who, profiting by all the labours of his predeceſſors, and adding to them many of his own, began to write in a correct and rational manner concerning antimony. His Treatiſe, publiſhed at the end of the ſeventeenth century, contains a multitude of curious experiments and exact proceſſes upon antimony and its ſulphuret. Mender has alſo, in an expreſs treatiſe, given a very complete hiſtory of it. Manget, in his Bibliotheque Chimique, has collected many treatiſes concerning the ſulphuret of this metal. There exiſt many other particular and monographic treatiſes upon this body, and there has ſcarcely been any able chemiſt who

has not made ſome particular inquiries, ſome diſcoveries, or at leaſt ſome eſſays relative to this ſubſtance. Geoffroy has inſerted ſeveral memoirs relating to it in the volumes of the academy. Bergman publiſhed, in 1782, a very well written Diſſertation concerning the numerous and varied ſulphureous combinations of antimony. Scheele, Macquer, and Rouelle have alſo given different proceſſes for preparing valuable antimonial remedies. A great number of phyſicians have invented and extolled particular formulas of which this metal and its ſulphuret formed the baſe; of theſe we may form an idea from the Table of theſe remedies, publiſhed at London, in the year 1773, by William Saunders.

4. To theſe immenſe ſources are to be added the innumerable antimonial preparations, that have been deſcribed and celebrated, for even more than eighty years paſt, in the pharmacopeias, formularies, diſpenſatories, all of which preſent ſome particular facts relative to its chemical hiſtory, and have had ſome influence upon the knowledge of the properties of this metal. Though it would be impoſſible as well as faſtidious and uſeleſs to give an exact ſtatement of all the diſcoveries contained in theſe almoſt innumerable works, we ought at leaſt be ſure of over-looking no eſſential circumſtance in methodically arranging the expoſition of the chemical characters of antimony; beſides, we ſhall ſee that the

thouſands of experiments and inquiries that have been undertaken relative to this ſubject, refer to a certain number of general and leading facts, none of which ſhall be neglected or forgotten in this article. The pneumatic doctrine, by explaining with great clearneſs and extreme preciſion, all the diſcoveries and all the preparations that appertain to this metal, has greatly contributed to ſimplify its hiſtory; and the methodical nomenclature, by giving exact ideas of all the different compounds to which it gives riſe, has diſſipated the obſcurity in which barbarous, myſterious, and ridiculous names had involved this part of chemiſtry.

B. *Phyſical Properties.*

5. ANTIMONY extracted from its ore and in a conſiderably pure ſtate, or dug out of the earth which frequently affords it in a native ſtate, as we ſhall ſoon ſee, has very diſtinct and well characterized properties. It is of a white, pure, brilliant colour, much reſembling that of ſilver or tin; its lamellated texture is manifeſtly compoſed of plates which ſeem to interſect each other in every direction, and which have greatly embarraſſed Citizen Haüy in diſſecting them in order to determine its form. It frequently preſents at the ſurface of thoſe orbicular cakes, rounded and convex on one ſide, and flat on the other, which we meet with in the ſhops, very perceptible traces of

cryſtallization, which have been deſcribed as herborizations, fern-leaves, feathers, or ſtarry rays. The alchemiſts placed a greater value upon that on which they ſaw this ſtar ſhine, which they conſidered as a favourable omen for their labours. Its ſpecific gravity is 6,702. Citizen Guyton places it in the ſeventh rank with reſpect to hardneſs, and at the ſide of lead; but it is ſenſibly harder than the latter, which it eaſily ſcratches: it has no ductility, and eaſily breaks under the ſtroke of a hammer. It may even be reduced into a fine powder, which is of a grey-white colour.

6. Its power of conducting heat, and its dilatability by this agent have not yet been determined with relation to other metals, for as it is not ductile, it is not neceſſary for the arts that this property ſhould be aſcertained. It is not fuſed until it has been heated to perfect redneſs, and it is ranked by the chemiſts amongſt the metals of a middling fuſibility. Citizen Guyton eſtimates a temperature of 345, according to Reaumur's ſcale, to be ſufficient for fuſing it. When we continue to heat it after its fuſion in well-cloſed veſſels, at the moment when it is of a white-red colour, it riſes in vapour, and is ſublimed and condenſed at the upper part of the crucible in brilliant and manifeſtly cryſtallized laminæ. If we ſuffer it to cool ſlowly after having fuſed it, and if, by perforating the ſolid cruſt which forms at its ſurface, we ſuffer the liquid portion

tion to run out, we find the internal cavity left by this decantation lined with pyramidal cryſtals, ſmall octahedrons, and ſeveral other ſecondary forms manifeſtly formed by octahedrons; when it becomes entirely fixed without any fluid portion being ſeparated, it preſents in its fractures large laminæ, which croſs each other in various directions, and which, as I have already obſerved, render it very difficult to determine its form: this ſtructure is the moſt complicated of any that Citizen Haüy has yet had occaſion to obſerve. In maſſes of antimony purified by ſeveral repeated fuſions, he has found, by attacking very ſenſible joints, twenty different directions; however, he has diſcovered this metal to be diviſible in directions parallel to the faces of a regular octahedron, and at the ſame time to thoſe of a rhomboidal dodecahedron; and he has found, by adopting the moſt probable hypotheſis of this ſpecies of undetermined problem, that the octahedron, compoſed of an infinite number of ſmall regular octahedrons connected by their edges, each of which was an aſſemblage of ſix ſmaller tetrahedrons united by their faces, by giving the primitive form, explains the almoſt infinite number of joints, the one parallel to the faces of the regular tetrahedrons, and the others to the faces of the tetrahedrons of which theſe are compoſed, which are found in the diſſection of this metal: ſo that by this diſſection,

ſection, we arrive at the double reſult that has been announced.

7. Antimony has a very perceptible ſmell and taſte, which are perceived when pieces of this ſubſtance have been held and rubbed for ſome time in the hands. It is to theſe properties that phyſicians aſcribe the very decided effects which this metal produces in the animal economy, as an emetic and purgative. Some have, however, believed that it produced theſe effects only as an oxide, and when it met with acids in the firſt paſſages.

C. *Natural Hiſtory.*

8. ANTIMONY has hitherto been found in nature only in four different ſtates: the firſt is that of native metal; the ſecond, that of ſulphuret of antimony; the third, hidro-ſulphurated oxide of antimony; and the fourth, muriate of antimony.

9. *Native antimony* was firſt found, in 1748, at Sahlberg, in Sweden, by Anthony Shwab; Schreiber diſcovered it afterwards in abundance in the mines of Altemont, in the province formerly called Dauphiné, now the *Department de l'Iſère.* This native antimony is eaſily diſtinguiſhable by its colour, its brilliancy, its large laminæ; ſometimes it is mixed with arſenic; but this ought not to be conſidered as a particular ore as ſome mineralogiſts have done,

who have deſignated it by the name of white or arſenical ore of antimony.

10. The ſulphuret of antimony is of a grey metallic colour; it ſoils the fingers like black chalk, but its ſurface is much more brilliant, and never grows dull by friction. When this ore, which is very abundant in France and Hungary, is well cryſtallized, it preſents ſquare priſms, ſlightly rhomboidal, terminated by a pyramid with four faces, reſembling that of the regular octahedron. This cryſtal divides very neatly parallel to the two moſt projecting or moſt acute edges of the priſm; in the pyramid the diviſions are parallel to the edges which anſwer to the baſes of the priſm; finally, by the light of a taper, we ſee ſome that are parallel both to the ſides of the priſm, and to its baſes. Citizen Haüy has not yet found cryſtals ſufficiently complete to aſcertain the difference of ſome degrees neceſſary for determining the primitive form of this ſulphuret. He only announces that the ſtructure deſcribed ſeems to indicate a difference between the form that has hitherto been found, and that of the rectangular priſm, or of the cube, or of the rectangular octahedron, which are the forms moſt familar to the metallic ſubſtances. Mineralogiſts have greatly multiplied the varieties of the ſulphuret of antimony, according to the arrangement, the ſeparation, the union, the volume, and even the irregularity of the priſms or needles of this ore: ſuch are

the *ſpecular* ſulphuret of antimony, the *ſtriated*, the *needled*, the *ſtellated*, the *lamellated*, the *chatoyant*, the *coloured*, the *irregular*. They have alſo given it ſome names of other ores, when it is found to contain certain metals: and in fact, we frequently find in it ſilver and iron, as in that of Himmelfurſt, near Freyberg; other ſamples are more or leſs charged with arſenic.

Amongſt theſe varieties we muſt diſtinguiſh that which preſents bundles of very thin needles, forming the tranſition to a capillary effloreſcence, compoſed of grey ſilky and elaſtic fibres; this is the ore of antimony in a grey-down, which Baron Born juſtly refers to the ſulphuret of antimony.

12. *The hidro-ſulphurated oxide of antimony*, termed *ore of antimony in red filaments*, or native *kermes* and *golden ſulphur*, is found in fine ſhining filaments, of a deep and dark-red colour, diſpoſed in radii diverging from a common centre, or in a kind of red incruſtation, tarniſhed, adhering to the ſurface and in the cavities of the ſulphuret of antimony; it varies by its caſt, which is ſometimes light, but moſt frequently browniſh, and by its cryſtalline or maſſy form, or crumbly ſtate. It is now known to be a natural combination of oxide of antimony, ſulphur and ſulphurated hidrogen: it yields this laſt ſubſtance in the form of gas, with efferveſcence and a fetid odour, when it is treated by the acids; it will

be better known hereafter, when I ſhall explain its artificial preparation and its properties.

13. *The muriate of antimony.* This was for ſome time conſidered as a white oxide of antimony; it is found at the ſurface of other ores of antimony or upon different gangues, in two different forms; either in rectangular laminæ, of a brilliant and pearly white, diviſible in a direction parallel to the larger laminæ, and reſembling the ſtone termed *Stilbite*; or in ſmall divergent needles, analogous in appearance to the radiated *Zeolite*, or to certain tremolites. It is immediately recognized by its property of fuſing when expoſed to the flame of a taper, and of emitting a vapour, which condenſes and attaches itſelf in a white powder to the ſpoon in which it is held. This ore is very little abundant, and it is rarely met with.

D. *Aſſays and Metallurgy.*

14. THOUGH it is generally a matter of no intereſt to the arts to know the quantity of metal contained in the ſulphuret of antimony, this knowledge is, however, frequently neceſſary in chemiſtry, and in the operations belonging to ſeveral of the arts. There are two proceſſes by which the ſulphur is ſeparated, and the metal obtained in a pure ſtate: the one conſiſts in ſlowly roaſting the ore till the greater part of the ſulphur has been diſengaged and burning the metal in a gentle fire, till it is

reduced into a grey oxide, ſtill ſulphurated, which ſhall be deſcribed hereafter; and afterwards mixing this oxide with its weight of black flux and a ſmall quantity of black ſoap or oil, and heating it pretty ſtrongly in a crucible till the metal is well fuſed and collected at the bottom of this veſſel. The black flux ſerves to reduce the oxide by its carbon, and to take away the remainder of the ſulphur by its alkali. In the ſecond proceſs, which is more expeditious and frequently more certain, nitre is employed, the quantity of which is proportioned to that of the ſulphur, in order that only the ſulphur may be burned and the metal left alone. For this purpoſe, eight parts of ſulphuret of antimony in powder, ſix parts of tartar, and three of nitre are taken. Theſe three ſubſtances, accurately mixed and pulverized, are thrown by ſpoonfuls into a large crucible ſurrounded with charcoal, and ignited in a furnace which gives a ſtrong heat. A lively detonation takes place at each projection; the tartar forms black flux, by its ſemi-combuſtion with the acid of nitre; and the ſulphur of the ſulphuret of antimony being burned, the metal is fuſed without being able to become oxidated on account of the carbon of the tartar with which it is ſurrounded, and the liquid alkali with which it is covered; the part of the ſulphur which eſcapes the combuſtion, combines with the alkali and forms ſcoria, which ſwim at the top of the metal.

The whole is poured into a greaſed and well heated iron cone, then agitated, by ſtriking the ſides of the cone, in order to collect the antimony at the bottom of this veſſel, and when it is ſufficiently cooled, it is extracted in a button generally marked at its ſurface with needles diſpoſed in the form of a ſtar. This ſtar proceeds from the circumſtance that as the cooling commences at the ſides, the fluid is thrown from the centre to the circumference. However, this cryſtallization can take place only in the ſmall buttons of antimony: in the larger maſſes, ſuch as the cakes which are ſold in commerce, the fluid ſubſtance, being caſt into flat moulds, experiences an undulation in ſeveral parts at the ſame time, and aſſumes ſeveral centres of cryſtallization; ſo that inſtead of a ſtar, we find impreſſions reſembling fern-leaves. Moreover, Reaumur has ſhown that a ſudden refrigeration prevents the ſtar-like cryſtallization, and that only the half of this ſtar is obtained when one of the ſides of the cone is ſuddenly cooled. Though the ſulphuret of antimony contains nearly three quarters of its weight of metal, it is not obtained entire, becauſe part remains in oxide combined with the ſulphur and alkali in the ſcoria. Accordingly, theſe are very much compounded, as we find in them, by an exact analyſis, undecompoſed nitre, charcoal, ſulphate of pot-aſh, hidrogenated ſulphuret of pot-aſh, with ſulphurated and hidrogenated oxide of antimony.

15. Bergman, in his Diſſertation on the humid analyſis, gives different proceſſes for aſſaying the different ſpecies of ores of antimony. The native metal ought, according to him, to be treated with the nitric, or rather the concentrated nitrous acid, and reduced into oxide, the weight of which ſerves to determine its quantity and purity. The ſulphuret aſſayed by the nitro-muriatic acid gives the ſulphur ſeparated upon the filtre. The metal oxidated and diſſolved in the mixed acid being treated again with concentrated nitrous acid which is made to boil, is depoſited in the ſtate of oxide. The ores of antimony which contain arſenic, yield the latter ſeparated, and ſhow its proportion, when we cauſe them to boil ſlightly in the nitro-muriatic acid, in order to ſeparate the ſulphur from them; when we treat the ſolution which contains the antimony and arſenic with concentrated nitric acid which is brought to ebullition, the oxide of antimony then becomes precipitated alone, and is collected upon the filtre; by evaporating the liquor we obtain the arſenic in the ſtate of arſenic acid; laſtly, the ſame chemiſt recommends us to employ the cauſtic fixed alkali, which, he ſays, diſſolves the ſulphur and the antimony, and ſeparates the ſilver or the other metals, which are not ſoluble in it. The laſt mentioned proceſs is adapted to the caſes of ores of antimony mixed with other metallic ſubſtances.

16. Operations in the large way, or the metallurgy of the ores of antimony, are applied only to the ſulphuret of this metal: not to obtain the metal from it; for this extraction is performed only in particular works far from the mines; and in general the ſulphuret of antimony is employed more abundantly and more frequently than its metal. Accordingly the working in the large way conſiſts only in the purification and a ſort of refining of this ore, for the purpoſes of ſeparating it accurately from its gangue and affording it pure to the arts in which it is employed. With this view, a large crucible, or earthen pot, is placed in the ground, in ſuch a manner that its ſides are upon a level with the ſurface, or a little elevated above it: this is a ſort of receiver; upon the firſt pot a ſecond is placed, perforated at the bottom, which enters into the upper part of the firſt and cloſes it pretty exactly: this upper crucible is, therefore, entirely out of the ground; into this latter the ore which is to be purified is introduced, broken into fragments; it is covered with a lid; then ſurrounded with coals, and the fire lighted, which is at firſt made very gentle, and gradually augmented; the ſulphuret of antimony runs through the holes with which the upper crucible is perforated, is collected in the crucible that is buried in the ground, and there becomes fixed by cooling. Some other fuſible ſubſtances alſo paſs, and form ſcoria above the fuſed ore. This

ſulphuret is afterwards extracted in cakes that have aſſumed the figure of the pot, and the maſs of which, being throughout cryſtalline, is needled or ſtriated in the interior parts. This is the ſtate in which it is met with in commerce.

As the mineral, purified in this manner, is uſed in making a great number of chemical and pharmaceutical preparations; as it has been employed in theſe preparations much more frequently even than the metal, I ſhall, in each of the following articles, treat with each of the agents of which the action will be there examined, both of Antimony as well as the ſulphuret of antimony, in order to preſent a more complete and more methodical hiſtory of the properties of this metal and of its ore.

E. *Oxidability by the Air.*

17. Antimony is one of the moſt combuſtible metals, and unites moſt ſpeedily and moſt ſtrongly with the atmoſpheric oxigen. In the cold, it experiences no ſenſible alteration from expoſure to the air; but when it is kept fuſed in contact with it, a white ſmoke ariſes which ſoon falls down upon the ſurface of the metal, or attaches itſelf to the upper part of the crucible, cryſtallizing there in the form of long and very ſlender priſms or of white ſhining needles. This ſublimed and cryſtallized oxide was formerly termed

argentine flowers, or *ſnow of regulus of antimony*. When we wiſh to prepare a certain quantity of it, we place a crucible filled with antimony obliquely in a good furnace, in ſuch a manner that the mouth of the crucible is upon a level with the interior orifice of the hearth; upon the firſt a ſecond crucible is adapted, ſupported obliquely and a little higher than the former, ſo as to ſerve as a receiver in this kind of ſubliming apparatus. Theſe two veſſels which are luted together with a little loam are not ſufficiently cloſed to prevent the air from penetrating into the interior ſpace. The metal becomes oxided, burns with conſiderable violence and is at the ſame time volatilized, ſo that its oxide being received into the exterior crucible, is condenſed in it, and attaches itſelf to it in long and beautiful cryſtalline needles, of a brilliant whiteneſs, and poſſeſſing a ſemi-tranſparency, of a vitreous appearance. A part of this oxide is pulverulent; it is detached by ſlightly ſhaking out the crucible which contains it upon paper. The antimony is found to have gained more than twenty per cent.

18. If, inſtead of treating the antimony in the manner that has juſt been deſcribed, it be heated very ſtrongly and to whiteneſs in a crucible, and afterwards agitated or ſhaken in contact with the air, it inflames with a ſort of exploſion, preſents while burning, a white light, and exhales into the air the white

oxide which it uſually yields. This property is alſo obſerved in treating antimony in the ſmall way with the blow-pipe. If when it is well fuſed upon charcoal, and at the moment when its ſurface is not covered with any particle of oxide, we throw it ſuddenly upon the ground, the globules into which it divides in its fall burn with a very lively flame, and throw out on all ſides brilliant ſparks which laſt for ſome time: when we afterwards examine theſe globules which have been inflamed by rapidly abſorbing and ſtrongly ſolidifying the atmoſpherical oxigen, we find them covered with a white powder, or having depoſited a light circle of this oxide upon the place where they reſt, or where they have cooled. This pretty experiment we have from Citizen Gillet, member of the council of mines.

19. The white oxide obtained by the ſlow or rapid combuſtion of antimony, either cryſtallized or pulverulent, approaches to the nature of an acid ſubſtance. It is ſapid, a little ſoluble in water; it is eaſily reduced by carbon; it remains fixed in the fire; and it fuſes at a high temperature into a glaſs of a clear hyacinth colour. It is employed for colouring glaſſes with an orange, or ſaffron-yellow tinge.

Citizen Thenars, in his intereſting reſearches relative to the oxides of antimony, has found that this retains 0,20 of oxigen, that it is eaſily reduced, even without any addition, and that by operating in a tube of porcelain we may obtain the metal by the mere action of the fire; that if we heat it ſtrongly and cautiouſly in a crucible, it paſſes, as it becomes ſucceſſively diſoxided, firſt into the ſtate of a yellow oxide eaſily fuſible into glaſs, containing 0,19 of oxigen, then into the orange-coloured oxide, containing 0,18 of this principle; afterwards into chocolate brown oxide, charged with 0,16 of oxigen; and laſtly, that it arrives at the ſtate of black oxide, containing only 0,02 of oxigen, before it re-aſſumes the metallic ſtate. Theſe different oxides are of great importance to be known, on account of their relation with ſeveral antimonial combinations that will be deſcribed hereafter.

20. The ſulphuret of antimony, heated upon charcoal, with the blow-pipe, is fuſed, runs, exhales a white ſmoke which attaches itſelf to the coal in a powder of the ſame colour, and at laſt penetrates the ſubſtance which ſupports it, and diſappears leaving a white circle round the place where it has been abſorbed. When this ſulphuret is expoſed in the ſtate of a fine powder to a ſlow fire, upon an earthen plate, ſo as to have much contact with the air, and frequently agitated, it is converted after the application of the fire has been continued about fifteen or eighteen hours, into a greyiſh powder, frequently mixed with particles that are ſtill brilliant, and which eaſily forms ſoft lumps when it is heated a little more ſtrongly. This

powder which was formerly termed *grey calx of antimony*, and at preſent *grey ſulphurated oxide of antimony*, is oxidated antimony that has loſt the greater part of its ſulphur. The ſulphuret when converted into this ſpecies of oxide, is diminiſhed in the proportion of between twenty two, to twenty three parts in a hundred. Bergman admits that it contains, in a hundred parts, about five parts of ſulphur, ſo that the grey ſulphurated oxide of antimony ſeems to conſiſt of about 0,78 of antimony, 0,16 of oxigen, and 0,06 of ſulphur. This oxidation, and deſulphuration of the ſulphuret of antimony affords a ſulphureous ſmell, and raiſes into the air a ſmall quantity of oxidated antimony; when the operation is performed upon a large quantity of the ſubſtance, this vapour is pernicious, at leaſt unleſs it be performed under a chimney that has a good draught. The ancient chemiſts ſuppoſed the exiſtence of ſome arſenical matter in the ſulphuret of antimony; but it produces this effect by the peculiar nature of its oxide.

21. When we heat the grey ſulphurated oxide of antimony rapidly, and with the aid of a ſtrong bellows, it is fuſed in the ſpace of ſome minutes into a beautiful tranſparent glaſs of a hyacinth colour. This is the glaſs of antimony of the ancient chemiſts, the tranſparent vitreous ſulphurated oxide of the ſyſtematic nomenclature. It is to be remarked that when the oxidation and the roaſting of the ſulphuret has

been continued till all its brillianey has diſappeared, and till it is whitened or approaches to whiteneſs, we have only an opaque ſcoria; which ſhows that the preſence of ſome hundredths of ſulphur is requiſite to the preparation of this glaſs. Accordingly, in order to give it its tranſparency and beauty, it is ſufficient to add to it a little ſulphur or ſulphuret of antimony, which even greatly accelerates the fuſion. When, on the contrary, we heat the grey ſulphurated oxide of antimony with twice its weight of black flux, or ſtill better with a mixture of one part of white flux, and one part of tartar, in a crucible, with a good fire, for ſome minutes, we obtain 0,78 or 0,79 of pure antimony. I have already indicated this proceſs in the deſcription of the aſſays of this ore.

22. In order to prove the nature of the glaſs of antimony by ſyntheſis, Bergman combined oxide of antimony immediately with ſulphur, in the proportion of eight parts of the firſt, and one of the ſecond; by fuſing this mixture in a crucible, with the blaſt of the bellows, he obtained real vitreous and tranſparent ſulphurated oxide of antimony. He has remarked that by fuſing for the ſame ſpace of time, about ſeven minutes, two parts of oxide, and one part of ſulphur, the ſulphur was volatilized, and that the ſulphur being thus fuſed, and ſublimed with a ſtrong fire, carried with it the oxide of antimony; that four parts of oxide

with one of ſulphur gave a black, and as it were fibrous maſs, whilſt ſixteen parts of oxide, and one of ſulphur yielded a greeniſh glaſs. He adds, as a character of the glaſs of antimony, that when heated with the muriatic acid, it exhales ſulphurated hidrogen gas. He propoſes with reaſon to prepare the glaſs of antimony for pharmaceutical purpoſes, by combining the oxide of antimony with the ſulphur in the firſt proportion that has here been indicated, in order to have this preparation conſtant. He has taken for his experiments the oxide of antimony formed by means of nitre; but it is to be remarked that, that which is the product of oxidation in the air is affected very nearly in the ſame manner as the former.

E. *Union with the Combuſtible Subſtances.*

23. It is not known whether there exiſts any combination between antimony and azote, hidrogen and carbon, which, amongſt the combuſtible bodies, have yet ſhown but very little action upon moſt of the metallic ſubſtances. Carbon acts with much energy upon the oxide of antimony, deprives it of its oxigen at a red heat and reduces it. The hidrogenated compounds, or the carbonated hidrogenous ſubſtances, the oils, the reſins, the fats, produce the ſame effect upon this oxide at a very high temperature, and cauſe it to return into the

metallic ſtate. This operation has however always been conſidered as difficult. It has been ſaid that it ſucceeds only in part, and that but very little well-reduced antimony is obtained. In fact, the maſs, after having been ſtrongly heated, frequently remains in the ſtate of a black, ſpongy, inflated ſcoria, and this ſcoria is commonly pyrophoric ; it inflames and burns with rapidity, like a fire-work, when the matter contained in this veſſel is ſtirred with an iron rod. However the experiments of Citizen Thenars have rendered theſe phenomena eaſy to be accounted for ; it appears that the carbon oppoſes the fuſion of the antimony, that its white oxide returns into the ſtate of black oxide, and remains in this ſtate in a light and ſcorified form, in which it is generally pyrophoric.

24. Antimony unites very well with phoſphorus. Pelletier, who is the firſt who has occupied himſelf with the preparation and the properties of the metallic phoſphorets has formed that of antimony in three ways, either by heating one part of vitreous phoſphoric acid with one part of antimony, and an eighth of carbon, or by fuſing equal parts of this vitrified acid and antimony in powder without carbon, or by throwing phoſphorus upon the metal in the fuſed ſtate, in a crucible. The ſecond of theſe proceſſes proves that antimony heated to redneſs has more attraction for oxigen than phoſphorus has, as the phoſphuret of

antimony which is formed in this caſe cannot be formed without the acid glaſs being decompoſed and unburned by the metal. By every one of theſe three means, Pelletier has obtained a brilliant metallic phoſphuret, brittle, of a lamellated fracture with ſmall ſquare facets, ſimilar and equal in three proceſſes. This phoſphuret, when placed upon a well-ignited coal, is fuſed, yields a ſmall green flame, and exhales white oxide of antimony. Pelletier obſerves, that this phoſphorated combination reſembles that of arſenic with the ſame metal, in the form of its ſmall facets. It appears that it is more fuſible than antimony. This combination, like all thoſe of the metals with phoſphorus, has yet been only touched upon, or but very ſlightly examined, and it merits all the attention of chemiſts.

25. Antimony combines eaſily with ſulphur, and forms, by this artificial combination, a ſulphuret of antimony perfectly ſimilar to that which exiſts in nature. On fuſing the mixture, we perceive that it is much more fuſible than the metal itſelf; that this abſorbs only a little more than a quarter of its weight of ſulphur; that it aſſumes the priſmatic or needled form, and the brilliant grey colour, inſtead of the lamellated texture and the white colour which it had before. We may bring this artificial ſulphuret of antimony to cryſtallize like the natural one, by cauſing it to cool ſlowly, and by ſeparating the portion which is ſtill

liquid; in other reſpects it acts in all experiments like the native ſulphuret of antimony, and might be employed and prepared for the ſame uſes, if nature did not afford it in great abundance.

26. Antimony combines eaſily with many metallic ſubſtances. In general, its alloys are lamellated and brittle. Amongſt the metals that have hitherto been examined, we only know the combination of antimony with arſenic and biſmuth. We know that theſe alloys have ſmall facets, that they are very brittle, very hard, and eaſy to be fuſed. Thoſe which it forms with tungſten, molybdena, titanium, uranium, nickel, cobalt, and maganeſe, have not yet been examined. Theſe metals have, for the greater part, been too little examined hitherto for it to be poſſible to determine with preciſion their combinations with each other, or with other metallic ſubſtances.

27. As little has the action been yet appreciated which various combuſtible bodies, eſpecially hidrogen, carbon, and phoſphorus, exert upon the ſulphuret of antimony. Sulphur cannot act upon it, as the metal is already ſaturated with it in this combination. However we ſhall ſee hereafter that by adding ſulphur in ſome combinations, the properties of the reſulting compounds are ſingularly modified. Several metals, amongſt thoſe which remain to be examined, poſſeſs the property of taking away the ſulphur from antimony in a red

heat, and of decompoſing its ſulphuret, as will be ſhown in the hiſtory of theſe metals. The alchemiſts formerly made great uſe of this property, and placed great confidence in what they termed the *Regulus*, or the alloyed antimony, proceeding from this operation.

28. It has already been proved (No. 22.) according to the experiments of Bergman, that the oxide of antimony, heated and fuſed with ſulphur, forms vitreous compounds more or leſs of a hyacinth colour, which reſemble the glaſs of antimony. We ſhall here add, that in theſe combinations, ſulphurated hidrogen gas is produced, which unites with the oxide and the ſulphur, ſo that theſe compounds are hidro-ſulphurets, or hidro-ſulphurated ſulphurets. This proceeds either from the circumſtance that the oxide which Bergman adviſes us to take retains a little water; for he recommends it to be well waſhed, and we ſhall ſee hereafter for what reaſon; or that the combination abſorbs atmoſpherical water, and decompoſes it: the latter fact indicates that the oxide of antimony here acts after the manner of the alkalis. The Swediſh chemiſt obſerves, that the glaſs of antimony, prepared in this manner by fuſion, yields ſulphurated hidrogen gas when it is heated with the muriatic acid, whilſt a ſimple mixture not fuſed, but merely triturated, of the oxide of antimony and ſulphur, does not yield gas by the action of this acid. The union between the

two ſubſtances, effected by fuſion, is therefore neceſſary to the decompoſition of water.

29. We have alſo ſeen (No. 22.) that, according to the proportions of oxide of antimony and ſulphur, which we combine by fuſion, we obtain different compounds. I ought here to add, according to Bergman, (Experiment 36, in his Diſſertation on the Sulphurated Antimonials) that by heating in a crucible equal parts of oxide of antimony, retaining a little water, according to his method of preparing it, and ſulphur, with a gentle fire raiſed only to the degree neceſſary for fuſing or ſlightly ſoftening the mixed maſs, a brown compound is obtained, analogous to the preparation known by the name of *Kermes Mineral*, of which I ſhall ſpeak hereafter. Here, ſtill more than in the Artificial Compoſition of the *Glaſs of Antimony*, which has been ſpoken of in Nos. 22 and 28, ſulphurated hidrogen is formed, which enters into the combination; for the Kermes contains more of this ſubſtance than the glaſs of antimony. By the explanations that will be given, this ſimple enunciation will ſoon be comprehended.

30. A combination, very analogous to theſe hidro-ſulphurets of antimony, is effected by a proceſs which had eſcaped the ſagacity of Bergman, and which Citizen Berthollet has lately applied to great advantage, though it has hitherto been ſeen and indicated but in a vague manner by moſt chemiſts. Whenever the oxide

of antimony is treated with an alkaline ſulphuret, or with an hidro-ſulphuret, ſuch as water charged with ſulphurated hidrogen, this oxide unites with the latter, and at the ſame time with a greater or leſs quantity of ſulphur, ſo as to form compounds more or leſs of an orange or brown colour, in which the antimonial oxide and the ſulphurated hidrogen are the common elements, but which vary from each other in a very great number of proportions, followed by gradations very much diverſified in all their properties. As theſe compounds will come to be treated of more in detail, under the article relating to the treatment of antimony, and its ſulphurets by the alkalis and by nitre, I here indicate only the exiſtence of theſe compounds, and their formation by the immediate union of ſulphurated hidrogen, and the hidrogenated ſulphurets, with the oxide of antimony.

Action upon Water and the Oxides.

31. The reciprocal action of water and antimony has not yet been ſufficiently examined: in the cold, theſe two ſubſtances produce no ſenſible effect upon each other; but the ſame is not the caſe when the antimony is heated to redneſs and fuſed. It cannot be doubted that in this caſe the metal decompoſes the water; it has not been practicable to perform this experiment in an immediate manner, becauſe it is accompanied with a very dangerous detonation and

fulmination. Chemiſts have frequent opportunities of obſerving this fulguration, which takes place whenever fuſed antimony is in contact with water: in two of theſe accidents, both of which might have killed or grievouſly wounded the operators, I remarked a very brilliant white flame. I have no doubt, therefore, that the water, at a high temperature, is decompoſed by the antimony, and that the latter burns by the oxigen which it takes away from it; and we ſhall ſoon ſee that the ſame decompoſition takes place in the cold or in a ſlight heat, under a multitude of circumſtances, in which the antimony is aſſiſted by the addition of ſeveral other bodies.

32. Though the action of the ſulphuret of antimony upon water has not yet been ſtudied, many facts concur to prove that it exerts a more or leſs marked action upon this liquid, and that it takes from it its oxigen, even at temperatures conſiderably low, provided it be aſſiſted by the ſimultaneous action of the acids or the alkalis. It is this action, the knowledge of which was unfortunately wanting to Scheele and Bergman, which would have enabled them to diſcover ſtill more important truths than thoſe which we already owe to their genius, and which, as we ſhall ſee in the ſubſequent numbers, renders it much more eaſy and ſimple to comprehend and explain ſeveral phenomena which they obſerved and deſcribed, relative to the antimoniated preparations,

tions, without having been able even to ſuſpect the cauſe.

33. The oxide of antimony, when ſaturated with oxigen, cryſtallized into needles in its ſublimation, which has been deſcribed above (No. 17.) is ſoluble in water, according to the ancient obſervation of Rouelle the elder, to which chemiſts have not yet paid all the attention which it merits. Though the proportions, and eſpecially the properties of this ſolution, have been little examined, we however already know enough concerning it to ſee that by this ſolubility the oxide of antimony approaches to an acid nature. In fact, this ſolution unites well with the alkalis, and precipitates an orange-coloured powder from water charged with ſulphurated hidrogen. The oxide of antimony acts as an emetic upon the animal economy.

34. Antimony, which the facts that have been already cited entitle to a place amongſt the metals which abſorb oxigen moſt eaſily, and adhere to it rather ſtrongly, muſt for the ſame reaſon exert a marked action upon ſeveral oxides; and though it has by no means been yet ſubjected to all the experiments capable of well aſcertaining this action, what we already know is ſufficient at leaſt to enable us to judge of how great importance it would be to determine it with greater accuracy than has yet been done. By heat, antimony takes away oxigen, either

completely or in part, from ſilver, gold, mercury, copper, lead, and iron; it is true, that with reſpect to the three laſt mentioned metals, it ſeizes only that portion of this principle that adheres the leaſt to them, and which has been the laſt added to them. It is in this manner that it appears to act upon the metallic acids which it is capable of diſacidifying, though it is incapable of depriving their metallic radicals of the firſt portion of oxigen which reduces them into the ſtate of oxides.

35. The action of the ſulphuret of antimony upon the metallic oxides has not yet been accurately appreciated; but the energy with which this binary combuſtible ſeizes oxigen, and the property which it has already been found to poſſeſs (No. 32.) of decompoſing water, ſufficiently prove that this ſulphuret is capable of taking that principle from a part of theſe oxides, or of depriving them of the laſt portion that has been added, as being the leaſt adherent. Many of the compounds that have been imagined by the alchemiſts might ſerve to prove the facts if it were neceſſary.

Action of the Acids.

36. Cold ſulphuric acid experiences no alteration from antimony, neither does it cauſe antimony to undergo any. When we boil it upon this metal, ſulphureous acid gas is diſengaged with effloreſcence; and if we heat the ſubſtances to dryneſs in a retort, ſulphur is ſublimed:

limed: there then remains white oxide of antimony in the veſſel. If we do not urge the application of the heat to dryneſs, we have a white, ſoft, and humid maſs in the crucible; when we waſh this maſs with water, the liquid takes up the acid united with a ſmall portion of antimony, and leaves a large quantity of white oxide undiſſolved; a large quantity of water added to this ſolution precipitates from it alſo the ſmall quantity of oxide which it contains: when it is evaporated, it becomes turbid without affording any real cryſtallized ſalt. The earths and alkalis decompoſe it, and precipitate from it a white oxide, which is difficult to be reduced by carbon, according to the teſtimony of moſt chemiſts. There exiſts, therefore, no real ſulphate of antimony, and the metal, though very oxidable by the boiling ſulphuric acid, is not ſoluble in this acid, ſo that it acts almoſt as if it had itſelf aſſumed the character of acid.

37. The ſulphuret of antimony is ſcarcely attacked by the ſulphuric acid; when this acid is boiling, it effervesces with the mineral; much ſulphureous acid gas is diſengaged, but no ſulphurated hidrogen gas; there is no more oxide of antimony in ſolution than in the preceding caſe; the ſulphur, mixed with the oxide of antimony, remains at the bottom of the liquid; accordingly, this cannot be a proceſs proper for analyzing the ſulphuret of antimony, and ſeparating the ſulphur from the metal. The oxide

of antimony by fire, the grey ſulphurated oxide, and the glaſs of antimony are ſcarcely attacked by the ſulphuric acid. When we cauſe it to boil upon the coloured hidro-ſulphurated oxides, that have been treated of in Nos. 22, 28, 29, and 30, a ſmall quantity of ſulphurated hidrogen gas is diſengaged, without taking up the oxide and really ſeparating it from the ſulphur.

38. The ſulphureous acid exerts no action in the cold either upon antimony or the ſulphuret of antimony; in heat it appears that this acid is decompoſed, that the metal is oxidated, and that a ſulphurated ſulphite of antimony is formed. The ſulphureous acid takes the oxide of antimony from ſeveral of its ſolutions, and eſpecially from that by the muriatic acid; it forms in it a white precipitate, of an acrid and auſtere taſte, a true inſoluble ſulphite of antimony, volatile, and decompoſable by the action of the fire, fuſible previous to its decompoſition into a grey maſs, cryſtallizable at its ſurface, and hollow in the interior part, which is lined with ſmall cryſtals; reducible by carbon, from which the ſulphuric expels the ſulphureous acid, and which, in cloſe veſſels, yields by diſtillation a ſmall quantity of ſulphureous acid, and afterwards ſulphuric acid, leaving as reſiduum a ſubſtance of a brown colour, ſoluble in fixed alkali, and precipitable into a hidro-ſulphurated oxide of antimony by the muriatic acid.

39. The nitric acid, and eſpecially that which contains a ſmall quantity of nitrous gas is rapidly decompoſed by antimony, even in the cold. During this action a large quantity of nitrous gas is produced, accompanied with a very ſtrong red vapour; the rapidity of the oxidation of the antimony, which is inſtantaneouſly converted into a white oxide, preſents the idea of a real combuſtion. Sometimes alſo inflammation takes place. Not only the nitric acid is decompoſed in this experiment, but the water itſelf is partially ſo: ſo powerful is the attraction which the antimony exerts in this caſe upon the oxigen; the union of the azote of the firſt, with the hidrogen of the ſecond of theſe ſubſtances, produces ammonia, which combines with the nitric acid, and forms nitrate of ammonia, which has been taken for a portion of oxide united with the acid. When we treat the white and thick, or even dry maſs, which reſults from this action, with quick-lime, or the cauſtic fixed alkalis, the ammonia is diſengaged. There is no combination between the oxide of antimony and the undecompoſed portion of the nitric acid, when any of this remains. If there be a little of this oxide diſſolved in the acid, water precipitates it; we might ſay, that the antimony had paſſed into the acid ſtate, on obſerving the ſlight adheſion which it contracts with the nitric acid. The oxide formed by this proceſs has been conſidered as extremely difficult to be reduced; the metal cannot be

extracted from it without a great deal of labour. It is juſtly conſidered as one of the moſt refractory and irreducible acids that exiſt. Citizen Thenars, on examining it comparatively with ſome other white oxides, has found it to contain 0,30 of oxigen; it approaches to that which is produced by nitre; he has found it to be in fact difficult of reduction, but he has eaſily ſucceeded in reducing it by heating it with a ſmall quantity of antimony, in order to deprive it of its oxigen: by this means he has cauſed it to repaſs ſucceſſively through the yellow, orange and brown colours, which indicate, (as I have already ſaid relative to that which is made by the fire, and which contains 0,20 of oxigen,) progreſſive diminutions of its oxidation.

40. The ſulphuret of antimony is alſo attacked with violence, to uſe the common mode of expreſſion, by the nitric acid, eſpecially when we promote its action by caloric; the metal is oxidated and none of it remains in the acid: the mixture becomes much heated; a large quantity of nitrous gas is diſengaged, but no ſulphurated hidrogen gas; the ſulphur which is ſeparated, is found confuſedly mixed with the oxide of antimony at the bottom of the liquor; and we ſee accordingly from this fact that the nitric acid cannot be uſed in the concentrated ſtate, particularly for making the aſſay of the ſulphuret of antimony.

41. This acid exerts no action upon the oxide of antimony; it is not improbable that it may be diſſolved by the nitrous acid, on account of the property which this poſſeſſes, of abſorbing a certain portion of oxigen from many metallic oxides. It has not however been attempted; neither is the manner known in which the nitric and the nitrous acids act upon the ſulphurated oxides of antimony, or upon the hidro-ſulphurets of antimony. It is only known that the ſulphurated hidrogen is not diſengaged by the nitrous acid, but burned.

42. The muriatic acid appears to be that which of all acts with the greateſt difficulty upon antimony. The chemiſts who have particularly occupied themſelves with the ſolution of metals, have ſaid that this metal diſſolves by long digeſtion or by diſtillation in the muriatic acid. I have obſerved, that when this acid is left for a long time upon antimony in powder, it at length acts upon this metal, and diſſolves a ſufficient quantity of it to aſſume a ſomewhat yellowiſh colour from it. This ſolution can only take place when the metal is oxidated, and its oxidation in the caſe that has been quoted, can only proceed from the decompoſition of the water; however I have remarked no effervеſcence, or it has been ſo feeble, and at ſuch diſtant intervals, that I have not been able to perceive it. The white oxide of antimony diſſolves better in this acid,

and forms a colourleſs ſolution, which has ſome properties different from thoſe of the preceding; the one yields by evaporation ſmall cryſtals in deliqueſcent needles which are volatilized by the fire, and are precipitated and decompoſed by the contact of water; that of the oxide, according to Citizen Monnet, is fixed in the fire, and cryſtallizes into brilliant laminæ like the boracic acid; beſides it is decompoſable by water. This difference would deſerve to be confirmed by new obſervations. Bergman affirms that the muriatic acid has more attraction for the oxide of antimony than the other acids: this is proved in fact by the ſolution of them which it effects; whilſt the preceding acids oxide the antimony without diſſolving it, or quit it very readily.

43. The muriatic acid diſſolves the ſulphuret of antimony better, as it can operate without the aid of heat. During the ſolution, a ſtrong ſmell of ſulphurated hidrogen gas is diſengaged. When we heat the mixture the whole of the metal is diſſolved. According to Bergman, a docimaſtic quintal of ſulphuret of antimony, heated with the muriatic acid, yields about eleven cubic inches of ſulphurated hidrogen gas; beſides a ſmall quantity which remains in the water through which the gas paſſes. The ſame quantity of ſulphuret of antimony yields only two inches of this gas, when it is treated in the cold with the muriatic acid. This celebrated chemiſt remarks, that the gas

carries with it, and depoſits in the tube of glaſs which conducts it a ſmall quantity of kermes, or red hidro-ſulphurated oxide of antimony, which proves that the water is decompoſed; for the kermes contains antimony in the ſtate of brown oxide, and alſo ſulphurated hidrogen. The vitreous hidro-ſulphurated oxide of antimony, or the glaſs of antimony is equally diſſolved in the muriatic acid, with a diſengagement of ſulphurated hidrogen gas. It is however here to be obſerved, that this latter compound, which is obtained by fuſing oxide of antimony with an eighth of its weight of ſulphur, may probably be nothing more than a ſimple ſulphurated oxide, and not an hidro-ſulphuret, as we find with the alkaline ſulphurets; and as theſe ſuddenly form hidrogenated ſulphurets by the contact of water, and the liquid muriatic acid, it may well be the caſe that the ſulphurated oxide of antimony does not contain ſulphurated hidrogen, and that this is formed only at the very moment of the contact of the muriatic acid, and by the decompoſition of the water. This may probably be the nature of the difference between the *glaſs of antimony*, and the *kermes mineral.*

44. The oxigenated muriatic acid burns and inflames antimony with rapidity, when we throw this metal into the gaſeous acid; in proportion as the metallic powder touches this gas, each portion kindles and burns with a very brilliant white flame, which forms ſparks. The

metal falls in the ſtate of oxide to the bottom of the veſſel. In the liquid oxigenated acid the antimony is converted into a white powder, of which only a very ſmall portion remains diſſolved in the muriatic acid, on account of the large quantity of water which this liquid oxigenated acid contains, in which, as we recollect, it has very little ſolubility. The caſe is the ſame with the ſulphuret of antimony, the ſulphurated grey oxide, and the ſulphurated vitreous oxide of antimony; theſe three antimonial ſulphurets, when thrown into oxigenated muriatic acid gas, burn with a blue flame, becauſe it is only their ſulphur which is inflamed; and as it paſſes thereby into the ſtate of ſulphuric acid, I adviſe to treat theſe bodies with the liquid oxigenated muriatic acid in order to analyze them, and to aſcertain the quantity of ſulphur by that of the ſulphuric acid that is formed, which is determined by the acid of the muriate of barites; and that of the metal, or of the oxide by the weight of the firſt precipitate or white depoſition, which is ſeparated in this experiment. This method will have, it is true, the ſlight inconvenience of yielding an oxide more charged with oxigen than it was in the ſulphurated antimonials; but this is a very ſlight error; it requires only a ſubtraction of 0,02 or 0,04, of the oxigen of the precipitate obtained.

45. The nitro-muriatic acid has long been conſidered as the beſt ſolvent of antimony,

and in fact it oxidates and diſſolves it without reducing it into white pulverulent and inſoluble oxide like moſt of the preceding. This nitro-muriatic ſolution is more permanent than the others. However it is alſo decompoſable by water, and yields white oxide of antimony. There is no nitro-muriate of antimony, as ſome authors have pretended, but muriate of antimony in this ſolution. This liquid ſalt, the only permanent one, in which the oxide of antimony remains united with an acid, affords when we plunge iron or zinc into it, a blackiſh precipitate, a ſpecies of oxide of antimony containing 0,02 of oxigen, which, according to the obſervation of Citizen Thenars, becomes pyrophoric, and inflames ſpontaneouſly in the air, when dried with a gentle heat.

46. The ſulphuret of antimony is very well, and accurately decompoſed by a mixture of three parts of muriatic acid, and one part of nitric acid. The metal is completely diſſolved and the ſulphur remains alone, provided we employ a ſufficient quantity of the ſolvent, and cauſe it to boil ſlightly towards the end. When the action of this is terminated, 0,26 of pure ſulphur are obtained. During the ſolution a ſtrong ſmell of ſulphurated hidrogen gas is diſengaged; and nevertheleſs, according to the obſervation of Bergman, who gives this proceſs as a means of aſſaying the ſulphuret of antimony, we obtain leſs of this gas by the nitro-muriatic acid than by the muriatic: this

manifeſtly depends upon the circumſtance that the nitric acid decompoſes and burns it.

47. The ſame mixed acid eaſily attacks the ſulphurated and hidro-ſulphurated oxides, diſſolving the oxide and ſeparating the ſulphur; ſulphurated hidrogen gas is diſengaged from all theſe ſolutions; but Bergman obſerves that that of the hidro-ſulphurated oxide, made with equal parts of ſulphur and of oxide, gives the greateſt quantity; I ſhall occupy myſelf more in detail with this action in the ſubſequent numbers.

48. We do not know the action of the other acids upon antimony, its ſulphuret and its ſulphurated oxides; we have likewiſe no knowledge of that which might be exerted by the phoſphoric, the fluoric, the boracic, the carbonic, or by the four metallic acids. It is even difficult to combine moſt of theſe acids by way of double attraction, with the oxide of antimony united with their acids, ſince, as we have ſeen, there are but few of theſe permanent ſolutions which can be employed for that purpoſe. However as water alone renders the muriatic ſolution turbid, which is the moſt permanent of all, the acids which accompany this precipitating water frequently unite with the precipitated oxide. In this manner the ſulphureous acid forms a ſulphite of antimony when it is poured into the muriate of this metal, not becauſe it takes away the oxide from this acid, but becauſe it unites with it only at the moment when the water ſeparates it.

It is, therefore, probable that even in the caſe of double attraction, the phoſphoric, fluoric, boracic, and carbonic acids may be combined with this oxide, at the moment when they are poured diſſolved in water upon the muriatic ſolution of antimony. It will, therefore be practicable by preparing them by means of this proceſs, to obtain and examine theſe antimoniated ſalts, which have not yet been examined, though they well deſerve it.

I. *Action of the Saliſiable Baſes and the Salts.*

49. None of the earthy or alkaline ſaliſiable baſes exert any ſenſible action upon antimony. Its oxide only has the property of uniting with the earths during their vitrification, and of imparting to them a yellow colour, more or leſs of an orange caſt, or approaching to the hyacinth colour. It unites in a more direct manner with the pure or cauſtic alkalis, which render it more ſoluble, and form with it a kind of cryſtallizable ſalt, ſoluble, and decompoſable by the powerful acids; ſo that it then appears to act the part of an acid; we ſhall ſoon have another occaſion to ſpeak more at large concerning theſe ſalts.

50. All the alkaline ſubſtances exert a very marked action upon antimony. By means of this action, two principal medicines are prepared, which have much occupied chemiſts, the one under the name of Kermes mineral, the

other under that of *ſulphur auratum.* In order to underſtand the theory and the nature of theſe remarkable compounds, which form one of the moſt ſingular points in the hiſtory of antimony, I muſt firſt remark, that every pure alkaline ſubſtance, from barites to ammonia, has more or leſs the property of diſſolving the ſulphuret of antimony; that this ſolution, made in the dry way, and by means of fuſion, forms antimoniated alkaline ſulphurets; that theſe ſulphurets decompoſe water with much energy; that the water which is ſo often united with the alkaline ſubſtances, is ſufficient for converting its ſulphurets into hidro-ſulphurated ſulphurets; that in this change, whether it be made at the very moment of the fuſion, or take place only after the fuſion, and be owing then to the water which is added, or to that which theſe compounds abſorb from the atmoſphere, the oxigen of the water ſeizes upon the antimony which it oxidates; that its hidrogen unites with a portion of ſulphur, and that there reſults from the ſimultaneous combination of the oxide of antimony, of the alkaline ſulphuret, and of the ſulphurated hidrogen, a complicated compound, an alkaline and antimoniated hidro-ſulphurated ſulphuret, remaining at firſt in an equilibrium of compoſition, but ſoon loſing this equilibrium when we attempt to diſſolve it in boiling water. In this latter caſe, if there be a ſufficient quantity of alkali, the whole is diſſolved with the aid of heat; but the ſolution becomes turbid as it cools, and is divided into two ſubſtances, one of which depoſits itſelf in the form of a red, or brown-red powder, which is termed in general *Kermes,* and is the hidro-ſulphurated oxide of antimony; and the other, which remains diſſolved, is ſtill an alkaline and antimoniated hidro-ſulphurated ſulphuret, but containing a little more ſulphur, and leſs oxide of antimony than the firſt of theſe compounds.

51. This ſeparation into two new products, which conſtantly takes place in the ſolution of the antimoniated and hidro-ſulphurated alkaline ſulphuret, depends upon the circumſtance, that the alkali, at leaſt, unleſs it be very abundant, cannot in the cold retain all the ſulphurated oxide of antimony which it holds in the heat; and that which is depoſited in the form, and under the name of Kermes mineral, is in fact, ſulphurated and hidro-ſulphurated oxide of antimony. However, the portion of antimoniated ſulphuret which the liquor ſtill retains, differs from that which is ſpontaneouſly precipitated by cooling, by its containing more of ſulphur and leſs of oxide of antimony. Thus the entire maſs of this compound divides itſelf naturally into two different portions; the one more antimoniated and leſs ſulphurated, which cannot be kept in ſolution in the cold, and which is depoſited in a brown powder or in *Kermes*; the other leſs antimoniated and more ſulphurated, which remains in ſolution; which

is ſeparated only by the addition of the acids, with a leſs deep colour than the preceding, approaching more or leſs to the orange, and which is known by the name of Sulphur Auratum. This alſo may be divided into different hidro-ſulphurets leſs and leſs antimoniated, and more and more ſulphurated, accordingly as its precipitation is graduated, by employing only by degrees the acid neceſſary for ſeparating the alkali. Hence the ſulphura aurata of the firſt, the ſecond and the third precipitation, leſs and leſs of an orange colour, and more and more pale, the laſt of which is ſcarcely any thing but ſulphur.

It is neceſſary now to deſcribe the particular action of each of theſe baſes, or at leaſt, of thoſe which exert a remarkable action upon the ſulphuret of antimony.

52. Barites, ſtrontian, and lime diſſolve the ſulphuret of antimony ſenſibly, though in little abundance. It is ſufficient to agitate the cold ſolution of theſe baſes with this ſulphuret in the ſtate of powder for ſome moments, in order that theſe liquors when filtrated, may yield by the acids a precipitate of pale hidro-ſulphurated oxide of antimony, or of ſulphur auratum; but there is not a ſufficient quantity of oxide of antimony formed and diſſolved for real kermes to be depoſited without the addition of acids. It is very evident, that by the mere contact of theſe alkaline or earthy ſolutions, a ſmall portion of the antimony is here

oxidated by the decompoſition of the water, and a portion of the ſulphurated hidrogen united with the oxide that has been formed.

53. The fixed alkalis, cauſtic or pure, and ſolid, pot-aſh and ſoda, ſaturated in a mortar with ſulphuret of antimony, become ſoftened, aſſume a green colour, and form a ſoft maſs, of a fetid odour, by abſorbing a ſmall quantity of atmoſpheric water. If we afterwards ſteep this maſs in hot water, it diſſolves and depoſits by cooling a little *Kermes*, and afterwards by the acids *ſulphur auratum.* Ammonia does not act near ſo powerfully upon the ſulphuret of antimony as the fixed alkalis do in the cold; in heat it alſo acts very little, becauſe the caloric volatilizes the ammonia ſooner than it favours its ſolvent action upon the ſulphuret.

54. It is not by this ſimple mixture, this ſimple trituration, and by the ſole action of the alkalis in the cold, that the ſubſtances termed *Kermes mineral and ſulphur auratum*, or the brown and orange-coloured, more or leſs hidroſulphurated oxides of antimony are prepared for pharmaceutical uſes. The hiſtory and the examination of the proceſſes of their preparation ought here to precede the examination of their nature. In the firſt years of the eighteenth century, a perſon of the name of Simon, a brother apothecary amongſt the Chartreux of Paris, employed this medicine under the name of *Kermes Mineral*, and gave it conſiderable

celebrity by the cures which he aſſerted he had performed with it amongſt the religious of that convent. This is the reaſon why this compound was firſt called, for ſome time, the *Poudre des Chartreux*. Though the diſcovery of this medicine was really owing to Glauber, who prepared it with the ſulphuret of antimony and the liquor of nitre fixed by the charcoal; though the invention may alſo be aſſigned to Lemery, who had deſcribed it under another name in his Treatiſe concerning Antimony, it was introduced into the world as a new remedy. Brother Simon ſaid he had his compoſition from a ſurgeon of the name of La Ligerie, who had himſelf received it from one M. Chaſtenay of Landau, and he owed it to an apothecary, a pupil of Glauber. The fame of its good effects induced government to purchaſe it. Dodart, firſt Phyſician to the King, applied to La Ligerie to publiſh the receipt of the *Kermes Mineral*; and it was actually made public in the year 1720. The proceſs, much inferior to that of Lemery, conſiſted in boiling for the ſpace of two hours, eight parts of rain-water with one part of the liquor of nitre fixed by charcoal and four parts of ſulphuret of antimony broken into ſmall fragments, filtrating the boiling liquor, boiling again upon the ſame ſulphuret a fourth leſs of the alkali of nitre than the firſt time, diſſolved in eight parts of rain-water, and a third time one half of the ſame alkali with the ſame quantity of water, always upon the ſame ſulphuret; the three decoctions being mixed together were filtrated, and depoſited by cooling a brown red powder or kermes, which was waſhed with water till it paſſed off inſipid; the powder was dried, alcohol was burned upon it, and it was carefully triturated for uſe. This proceſs, which is very ill-contrived, and very tedious, affords but very little kermes, at moſt a fortieth part of the weight of the ſulphuret of antimony that has been employed. It was particularly faulty, on account of the ſmall quantity of alkali employed, which was very far from being ſufficient for the proportion of ſulphuret of antimony that was taken. Accordingly, the apothecaries never followed it, when this compound became ſufficiently known to be a very common medicine.

55. Lemery the younger, having claimed the diſcovery of this antimonial preparation, for his father, from the Academy of Sciences, his proceſs was generally adopted and practiſed in the laboratories of pharmacy, where the kermes mineral was, and ſtill is prepared in one or other of the two following ways. In the dry way, are taken ſixteen parts of ſulphuret of antimony, eight parts of alkali or tartar, and one part of ſulphur; theſe three ſubſtances are well mixed by trituration; they are fuſed in a crucible; the maſs when well fuſed, is poured into an iron mortar; it is coarſely pulverized when it has cooled; then boiled in a

ſufficient quantity of water, and the liquor being filtrated through grey paper, paſſes clear and with a ſlight orange tinge, with ſcarcely any other ſmell than that of the lixivium; in proportion as it cools there ſeparates from it a powder of a beautiful brown-red colour, or kermes, in great abundance, which is firſt waſhed in cold water, and afterwards in boiling water, then well dried, pulverized, and paſſed through a ſilk ſieve.

The kermes, by the humid way, is prepared in the following manner. In twenty parts of water are boiled ſix parts of fixed alkali, the pure pot-aſh of commerce; into the boiling liquor is thrown about one twentieth part of the weight of the alkali of pulverized ſulphuret of antimony; this mixture is well agitated, it is ſuffered to boil for ſeven or eight minutes, and filtrated; the liquor depoſits in cooling a large quantity of red powder, or kermes, which is well waſhed. By either of theſe proceſſes, nearly three quarters of the weight of the ſulphuret of antimony employed is obtained in kermes.

56. In both theſe operations, all the ſulphuret of antimony treated by the alkali is not converted into kermes mineral, and it has been remarked that the reſidue, eſpecially that of the humid way, contains ſcarcely any more ſulphur, and that by fuſing it in a crucible, it yields antimony almoſt pure. Hence it muſt be concluded, that the alkali diſſolves the ſulphur

almoſt entirely, and that it oxides only the portion of antimony which it diſſolves at the ſame time as the ſulphur. The liquors, which, in both operations, ſwim above the kermes mineral, or the mother waters which ſtill contain oxide of antimony diſſolved in the alkaline hidro-ſulphuret, may be precipitated by the acids, which firſt ſeparate from it deep-coloured hidro-ſulphurated oxide of antimony, containing a large quantity of antimony, and afterwards an hidro-ſulphurated oxide more and more pale, leſs and leſs antimoniated, and approaching at laſt to the ſtate of ſulphur. We have a proof that exactly the ſame ſeries of phenomena take place as were indicated above, Nos. 50 and 51; namely, that the alkali, by diſſolving the ſulphuret of antimony, favours the decompoſition of the water, cauſes its oxigen to ſeize the antimony which becomes oxidated in different degrees, and its hidrogen to ſeize a portion of the ſulphur; that it retains the ſulphurated and hidro-ſulphurated oxide of antimony; and that it effects, by cooling, a ſort of diviſion of the products, one of which is in the ſtate of hidro-ſulphurated brown oxide of antimony, which, being ſurcharged with metal oxidated to the brown ſtate, with relation to the whole maſs, abandons the ſolution, and is depoſited in the form of kermes mineral, and the other, in the ſtate of hidrogenated ſulphuret of orange-coloured oxide of antimony, remains in ſolution in the alkaline liquor. We have a proof of the real exiſtence of theſe phenomena, even in the property which the mother-water poſſeſſes of re-diſſolving the kermes, when we heat it. But it is to be obſerved, that in the ſecond precipitation which accompanies the cooling of this ſolution, another diviſion is made in the hidro-ſulphurated oxide of antimony, for this ſecond precipitate has another colour, ſome different properties, and eſpecially appears to contain other proportions in its principles than the firſt.

57. Before we were able to explain the theory of the operation of the kermes, which I have juſt preſented, the hiſtory of the ſcience exhibited a ſeries of fruitleſs reſearches and labours relative to the nature of this ſingular compound. Geoffroy is the firſt chemiſt who has occupied himſelf with the analyſis of the Kermes: he pretended that 72 parts were compoſed of 17 of metal, 14 of alkali, and 41 of ſulphur. It is evident that Geoffroy had examined only ill-waſhed kermes; for all the chemiſts who ſince him have operated upon this ſubſtance have found no alkali in it, or have found in it only particles that had eſcaped from the lixiviation. Bergman, in his very intereſting diſſertation on the ſulphurated antimonials, has committed errors, and has fallen into contradictions relative to the nature and compoſition of this ſubſtance, which are aſtoniſhing when we conſider the ability of the author. In one place in his work (Experiment 30.) he

ſays, that an hundred parts of kermes have yielded him, by the muriatic acid, 0,52 of white antimonial powder, and that he could not collect more than 0,08 of ſulphur, without ſpeaking of the 0,40 of matter loſt in this inaccurate analyſis. It is true that he ſays elſewhere, that he obtained from the ſame weight of this compound fifteen cubic inches of ſulphurated hidrogen gas; but this product does not ſupply the deficiency of 0,40. Beſides, he affirms, that an hundred parts of kermes contain 0,52 of metal (we have juſt ſeen that theſe 0,52 were white oxide of antimony, and not metal), and 0,48 of ſulphur: but he had ſaid, a little before that, that he had not been able to collect more than 0,08. Hence we may conclude, that the analyſis of the kermes mineral was not yet well performed by Bergman. It is known that this compound fuſes into *liver of antimony*, or opaque vitreous ſulphurated oxide; that, when treated by the muriatic acid, it loſes its colour, affords ſulphurated hidrogen gas; and that it is ſoluble in the alkaline ſulphurets and hidro-ſulphurets. Citizen Berthollet, by deſcribing it as a hidro-ſulphuret of oxide of antimony, has given a much more accurate notion of it than thoſe which had been preſented before him.

58. Citizen Thenars, in his reſearches concerning the oxides of antimony, has put the laſt hand to this work. From his analyſis of different antimonial preparations

compared with each other, ſeveral new truths reſult, which, whilſt they eſtabliſh the firſt truths announced by Citizen Berthollet, give them a preciſion which they did not before poſſeſs. According to Citizen Thenars, kermes is only a brown oxide of antimony, united with ſulphurated hidrogen, and a ſmall quantity of ſulphur. Its difference from the ſulphur auratum conſiſts leſs in the proportion of the ſubſtances than in the ſtate of the oxide. In the latter, the oxide of antimony is orange-coloured inſtead of being brown: it is to this varied ſtate of the oxide that theſe compounds owe their difference of colour. They are ſoluble in the alkaline hidro-ſulphurets, and not in the alkalis. Finally, the kermes acts upon the air, deprives it of oxigen, analyzes it as an eudiometrical inſtrument, becoming pale in proportion as it is more and more oxidated, and at laſt it becomes white altogether. Citizen Thenars has found, by a careful and laborious analyſis, for which he was obliged to re-analyze the ſulphuric acid, the ſulphate of barites and the ſulphurated hidrogen, that kermes mineral contains.

72,760	brown oxide of antimony;
20,298	ſulphurated hidrogen;
4,156	ſulphur;
2,786	loſs in water, &c.

The Sulphur Auratum contains:

68,300	orange-coloured oxide of antimony;
17,877	ſulphurated hidrogen;
11 to 12,000	ſulphur.

Theſe new reſults agree with the ancient experiments, the theory of which had not before been comprehended.

Kermes is prepared immediately by the mixing of a muriatic ſolution of antimony and of hidrogenated ſulphuret, or, ſtill better, of hidro-ſulphuret of pot-aſh: this mixture ſuddenly affords a precipitate of a brown-red colour, becauſe as the hidrogen takes away a little oxigen from the white oxide before it precipitates it. It is alſo formed by expoſing white oxide of antimony, wet, or ſteeped in water, to the contact of ſulphurated hidrogen gas, and according to the ſame theory. As to the proceſs by which Bergman imagined he had formed kermes, by fuſing, or rather by ſoftening together equal parts of ſulphur and of oxide of antimony, prepared by nitre (No. 29.) it is very evident that this is not a real kermes; for it does not contain a ſufficient quantity of hidro-ſulphuret to conſtitute it ſuch: it is only a fuſed ſulphurated oxide of antimony.

59. What I have here explained concerning the *hidro-ſulphurated brown oxide of antimony*, or *kermes*, of which I have been obliged to modify the firſt denomination of the methodical nomenclature, on account of the diſcoveries of Citizens Berthollet and Thenars, relative to the preſence of ſulphurated hidrogen, and of the different oxides of antimony, which determine its real nature, proves, that in order to make an exact analyſis, it was

neceſſary, after having eſtimated the proportion of ſulphurated hidrogen that is diſengaged from it by the action of the acids, to determine that of the ſulphur, by burning it completely by means of the nitric or oxigenated muriatic acid, and by precipitating the ſulphuric acid thus formed by the nitrate or muriate of barites, and that of the oxide of antimony, by diſſolving it in the muriatic acid, and precipitating it with water. I muſt alſo obſerve on this occaſion, that the acids cannot ſerve to analyze the hidro-ſulphurated oxide of antimony by ſimply ſeparating the ſulphur, and diſſolving its oxide, as has been believed; for in this operation, the ſulphur always retains a portion of oxide of antimony. I muſt, moreover, obſerve, that this hidro-ſulphurated oxide does not yield ſulphurated hidrogen gas by the action of fire, and that its hidro-ſulphuret appears to be decompoſed during its fuſion into vitreous ſulphurated oxide. Finally, I ſhall remark, that there appear to be different hidro-ſulphurated oxides of antimony, varying in the proportion of their principles, according to a multitude of different circumſtances that accompany their formation.

60. When the nature of theſe *hidro-ſulphurated oxides of antimony* has been well comprehended, that of the ſulphur auratum will be equally comprehended. Being more ſoluble in the alkaline ſulphurets than the firſt, they are ſeparated and obtained from them only by de-

poſing their ſolutions by the acids: they contain more ſulphur, leſs oxide of antimony, and this oxide leſs oxided than the kermes; they vary amongſt themſelves according to the mode of their preparation, and the proportions of their principles are very different. In order to obtain a conſtant proportion, Goetling has propoſed the following proceſs: mix well two parts of ſulphuret of antimony, reduced to a very fine powder, with three parts of ſulphur; diſſolve them in a boiling ley of cauſtic alkali; filtrate, dilute the ſolution with water, precipitate it by the diluted ſulphuric acid: in this manner are obtained nearly 4½ parts of an hidro-ſulphurated ſulphuret of antimony, ſimilar to that which is obtained by the third precipitation of the mother waters of the hidro-ſulphurated brown oxide of antimony. Bergman obſerves juſtly concerning this proceſs, that it is preferable to that which is generally practiſed in order to obtain it; that the proportion of its principles may alſo be varied, according to that of the ſulphur which is added at the option of the phyſician, who will then know what he ſhall poſitively employ.

61. I ſhall conclude this account of the properties of the ſulphurated and hidro-ſulphurated oxides of antimony, by obſerving, that theſe compounds, whether we form them by immediate fuſion with the metallic oxide and the ſulphur, or obtain them by the immediate union of the antimoniated ſolutions with the alkaline hidro-ſul-

phurets, or whether they be the product of the action of the muriatic acid upon the ſulphuret of antimony, or that of the action of the alkalis, always ſhow a more feeble adheſion, a leſs intimate combination between the molecules of the oxide of antimony and the molecules of ſulphur, than there exiſts in the ſulphuret of antimony; for theſe ſubſtances are more decomposable, ſince merely a long expoſure to the air is ſufficient to alter them, and they aſſume the vitreous chaact er in the fire. The preſence of the ſulphurated hidrogen which brings them to the ſtate of ſulphurated hidro-ſulphurets, and of triple compounds, is the cauſe of this ſmaller adheſion between their molecules, as the frequently larger proportion of ſulphur is its effect.

62. Amongſt the ſalts there is no claſs which is not ſuſceptible of being in ſome meaſure altered by antimony and its ſulphuret, and which does not at the ſame time change the nature of theſe bodies. Monnet is the firſt who has deſcribed the action of antimony upon the ſulphates of pot-aſh. By fuſing in a crucible one part of this ſalt, and half a part of antimony, the metal diſappeared; a maſs is obtained, ſeemingly vitrified or fritted, and cauſtic, which is an antimoniated ſulphuret of pot-aſh, and which, when diffuſed in hot water, yields hidro-ſulphurated oxide of antimony by cooling. The antimony has, therefore, taken oxigen from the ſulphuric acid, and has united

in the ſtate of oxide with the ſulphuret of pot-aſh which has been formed. The contact of the water, by its decompoſition, has quickly hidro-ſulphurated this antimoniated alkaline ſulphuret; ſo that its hot ſolution has become ſuſceptible of ſeparating itſelf into two portions; the one highly antimoniated, which is ſpontaneouſly precipitated in the brown ſtate; the other more ſulphurated, which has remained diſſolved. There is no room to doubt that moſt of the ſulphates, and even of the earthy and alkaline ſulphites, would experience the ſame change from the action of antimony. The ſulphuret and pure oxide of this metal, on the contrary, produce no kind of alteration upon them.

63. The nitrates are all capable of burning antimony and its ſulphuret, by heat, or in a red heat, more or leſs violently and completely, according to the quantity of them that is employed. This action has been made uſe of in order to prepare, with the aid of the nitrate of pot-aſh, the ſpecies of the genus which is preferred, as we have ſeen upon a former occaſion, a great number of different antimoniated preparations, of which I ſhall here mention the principal. A mixture of two or three parts of this ſalt, and one part of fine powder of antimony, well pounded in a mortar, detonates ſtrongly whether we place it in contact with ignited combuſtible ſubſtances, or throw it into a red-hot crucible, or heat

it to redneſs in a cloſe crucible. This latter method is preferable to the two firſt, which, by admitting the contact of the air, occaſion a loſs of a great part of the product of the operation, for it is known that antimony is volatilized by a ſtrong heat. The detonation is accompanied with a very lively white flame; the antimony is ſtrongly and completely oxided by the oxigen of the nitre, which is itſelf decompoſed and reduced to its alkaline baſe. The reſidue of this detonation is a white maſs, ſcorified, which, when waſhed with water, leaves a portion of the oxide of antimony united with a ſmall portion of pot-aſh, and gives another combined with much more alkali, and diſſolved like a ſpecies of ſalt, in which the oxide ſeems to perform the function of an acid. The oxide prepared in this manner was formerly termed *diaphoretic antimony by the regulus.* The undiſſolved portion of oxide of antimony was conſidered as a pure oxide; but Citizen Thenars has diſcovered that it retains a portion of pot-aſh which conſtitutes about a fifth of it, and that, in conſequence, the product of the detonation of the nitre and of the antimony, is divided into two parts by waſhing; namely, into a ſpecies of antimoniated pot-aſh which is diſſolved, and a ſort of inſoluble antimonite of pot-aſh.

64. This preparation is more frequently made with the ſulphuret of antimony than with the metal, becauſe, as has already been ſo often remarked, this ſulphuret has been much

more employed than the metal itſelf. Three parts of nitre, and one of ſulphuret of antimony, well triturated together, placed in an iron mortar, and touched with an ignited coal, inflame and continue to burn with emiſſion of ſparks, much activity, and very abundant white vapours, till the mixture is entirely converted into a maſs of a yellowiſh colour, half-fuſed or ſcorified, which retains for ſome time the redneſs of the ignition, and cools ſlowly. The quantity of nitre which is employed in this experiment, and the force of the combuſtion which it excites on account of the proportion of oxigen, burns the ſulphur and changes it into acid, as alſo the antimony which is found completely oxidated. The product conſiſts of ſulphate of pot-aſh, a little nitre eſcaped from the detonation, oxide of antimony united with the pot-aſh ; and it is ſuſceptible of being divided into two compounds by the action of water, as is done with the product of the combuſtion of pure antimony by nitre. This maſs was termed in Pharmacy, *ſolvent of Rotrou*, or *diaphoretic antimony not waſhed.* When it is thrown into hot water, it dilutes; the ſalts and a part of the oxide, united with the pot-aſh, diſſolve in it ; the greater part of the oxide combined with one fifth of pot-aſh, remains at the bottom of the water, in a white, inſoluble and almoſt inſipid powder. After it has been well waſhed and cleaned, it is formed into maſſes, dried, and kept under the name of *waſhed diaphoretic antimony.* The water of the lixiviation, which, beſides the nitre which is not decompoſed, but reduced to the ſtate of nitrite, and the ſulphate of pot-aſh, contains ſtill a portion of oxide of antimony united with this alkali in the ſtate of a ſalt, may be decompoſed by the acids, which form in it a precipitate of white oxide, termed *ceruſs of antimony*, or *pearly matter of Kerkringius*, becauſe it was known, and well deſcribed by this laſt Commentator on the Treatiſe of Baſil Valentin. Formerly the liquor that ſwam above this precipitate was evaporated; and the ſalt which was obtained from it, containing undecompoſed nitre, ſulphate of pot-aſh, and the new ſalt formed by the precipitating acid combined with the pot-aſh, however different it was, as all the acids could be employed for this precipitation, bore the improper name of *antimoniated nitre of Stahl*: but it is evident that, even when prepared by the nitric acid, it does not contain oxide of antimony, if its preparation has been well conducted.

65. I have already announced (No. 49,) that the oxide of antimony unites with the alkalis; and we have juſt ſeen a more direct proof of it, both in the undiſſolved part of this oxide, and in the lixiviation of the product of the detonation of antimony, and the ſulphuret of antimony with nitre. This lixivium contains a ſpecies of ſalt formed by the union of part of the oxide with the pot-aſh; a ſalt which might be named *antimonite of pot-aſh*, ſince,

according to the obſervation of Citizen Berthollet, it is ſuſceptible of cryſtallizing; it poſſeſſes a determinate degree of ſolubility; it is decompoſed by the acids. As to the reſt, I ſpeak under in a particular number, only in order to call the attention of chemiſts to the ſingular combinations of this acidiform oxide with the baſes, and to induce them to make new inquiries relative to theſe combinations which have as yet been only ſurmiſed. In general, the oxide of antimony made by nitre, or by the decompoſition of nitric acid, appears to be more oxidated, and more approaching to the ſtate of acid, than that which is obtained by the ſimple combuſtion of antimony fuſed in the air. It was with the oxide prepared by means of nitre, that Bergman made his ſulphurated preparations; it was by endeavouring to reduce it with ſoap, that Geoffroy diſcovered that pyrophorus burning like a fire-work, which I have already mentioned, (No. 23). Laſtly, this oxide of antimony, which is the moſt oxigenated of all, has been carefully examined by Citizen Thenars, who has found it to contain 0,32 of oxigen. The principal characters which he has diſcovered in it are, that it is the leaſt ſoluble in water of all the oxides of antimony, that it unites with the acids with the greateſt difficulty, that it requires for its diſoxidation the higheſt temperature, without being irreducible, as was formerly believed, that it cannot be well reduced unleſs when it is heated with a portion of antimony, which, by ſharing its oxigen which it takes away by degrees, cauſes it to paſs again through all the ſucceſſive degrees of oxidation; namely, from the white to the yellow, from the yellow to the orange-coloured, from the orange-coloured to the brown, and from the brown to the black.

66. If inſtead of employing three parts of nitre, and one part of ſulphuret of antimony, we employ only equal parts of theſe two ſubſtances, we obtain by the action of the fire an opaque vitrification, which has been termed *Liver of Antimony*. Bergman obſerves, what may apply to all theſe caſes of the combuſtion of the ſulphuret of antimony by nitre, that when we throw the materials at ſeveral times into a red-hot and open crucible, we may loſe nearly half the mixture; he, therefore, adviſes us to put the ſubſtance into a cold crucible, to cloſe it, and to apply the fire till it is fuſed. By this proceſs ſcarcely more than an hundredth is loſt. The ſame method is to be recommended for all the preparations which are made with nitre and antimony, or its ſulphuret. We thus obtain, under ſome ſcoria, an opaque well-fuſed glaſs of a deep brown colour, which is a real oxide of antimony, brown, ſulphurated and hidro-ſulphurated, vitrified, which was formerly termed *liver of antimony*, on account of its colour and opacity, to diſtinguiſh it from the *glaſs of antimony*, which is tranſparent and of a hyacinth colour. We ſee that here the pro-

portion of the nitre is not ſufficient to burn the whole of the ſulphur; we ſee alſo that the antimony burns before the ſulphur, as takes place in the preparation of the kermes. This liver of antimony, or antimoniated ſulphuret of pot-aſh, contains a ſmall quantity of ſulphite and of nitrate of pot-aſh, which Bergman believes to be the true *antimoniated nitre* of Stahl. He remarks alſo, that theſe ſalts prevent the deliqueſcence which the antimoniated ſulphuret formed ſimply with equal parts of fixed alkali, and of ſulphuret of antimony fuſed together, undergoes.

It is eaſily conceived from what has already been ſaid, that when this vitreous product is waſhed, the water, by taking up the ſalts, diſſolves alſo a portion of hidro-ſulphurated oxide of antimony, will depoſit by cooling a portion of real kermes, and afford by the acids hidro-ſulphurated orange-coloured oxide, or ſulphur auratum. The undiſſolved portion of *the liver of antimony*, well waſhed and reduced to powder, was termed *Crocus*, or *Saffron of Metals*, on account of its deep orange-red colour. Bergman conſiders it as a ſpecies of kermes or hidro-ſulphurated oxide of antimony; it yields ſulphurated hidrogen gas by the muriatic acid; and though it has not been ſubjected to an accurate analyſis compared with that of the kermes ſtrictly ſo called, it is evident, that it differs from it only by a larger proportion of oxide of antimony, and alſo by its more advanced ſtate of oxidation: it is likewiſe more active, more purgative and more emetic, on which account it is employed as a medicine for horſes. The ſcoria that is ſituated above the liver of antimony, is grey, and yields by lixiviation a cryſtallized ſalt, which is fuſed, ſwells with a noiſe before the blow-pipe, and preſents a ſpecies of detonation; it remains red or yellow for ſome time after its cooling, but its colour diſappears after ſome time. This ſalt yields ſulphurated hidrogen gas with much froth by the contact of the acids; and when fuſed afterwards with the blow-pipe upon a coal, it is abſorbed and leaves only a white circular trace in the place which it occupied. Bergman concludes from theſe experiments, that the ſalt of the ſcoria of the liver of antimony is a mixture of nitre and of ſulphite of pot-aſh, with ſome traces of oxide of antimony. He adds that theſe ſcoriæ yield ſulphurated hidrogen gas by the muriatic acid, before as well as after their being waſhed; but that they do not depoſit any hidro-ſulphurated oxide of antimony.

67. It will be recollected, that by treating eight parts of ſulphuret of antimony with ſix parts of tartar and three of nitre, we obtain antimony, becauſe the ſmall portion of oxigen of the nitre is employed to burn the tartar, to reduce it into a coal, which prevents the oxidation of the metal, and to burn a ſmall quantity of ſulphur, of which the larger part combines

with the pot-aſh, the baſe of the nitre, and of the tartar, (ſee No. 14). The ſcoria which float above the metal, and which are very abundant and very voluminous, are much compounded. We find in them antimoniated ſulphuret of pot-aſh, which, when waſhed with hot water, acts in perfectly the ſame manner as the lixivium afforded by the kermes mineral and the ſulphur auratum. It is mixed with ſulphate and ſulphite of pot-aſh, and much carbon. It is, therefore evident, that the antimony is not completely diſengaged by this proceſs, which is to be conſidered merely as an imperfect aſſay of its ore, ſince a portion, and even a pretty conſiderable one, remains oxidated and combined with the very abundant pot-aſh of the ſcoria.

68. Antimony appears to be capable of decompoſing the muriate of ſoda, according to Citizen Monnet, who aſſerts that when we heat a mixture of theſe two bodies in a retort, ſublimed muriate of antimony is obtained; but this chemiſt does not ſpeak of the reſidue, which he does not ſeem to have examined, and which ought to contain ſoda, if the ſalt has been really decompoſed. The antimony does not act upon the ammoniacal muriate, as Bucquet has convinced himſelf, and it yields neither ammonia nor muriate of antimony when it is diſtilled with this ſalt, as Juncker had, however, advanced.

69. It appears that the ſulphuret of antimony acts more upon the muriates, than the metal does, on account of the attraction of the ſulphur for the baſes of theſe ſalts. Thus by diſtilling a mixture of this ſulphuret with muriate of ammonia, we obtain, according to ſeveral chemiſts, a purple pulverulent ſublimate, which can only be an ammoniaco-antimonial hidro-ſulphuret. This experiment deſerves to be repeated with care.

70. The ſuper-oxigenated muriate of pot-aſh, the only one of this genus which is well known and employed, acts very powerfully upon antimony and its ſulphuret; mixed in the proportion of two parts to one of theſe combuſtible bodies, and inflamed by the contact of a body in the ſtate of combuſtion, it cauſes them to burn with ſuch great activity, that the whole is diſſipated in the air in a white vapour, leaving only a ſlight circular mark upon the body on which this mixture has been placed. When this experiment is performed in a cloſe veſſel, we obtain from the antimony a white oxide, which is ſeparated from the muriate of pot-aſh by the action of water, which diſſolves the latter; by this means we obtain the oxide perfectly pure and inſulated. When a ſudden ſtroke is given to the ſame mixture of ſulphuret of antimony, or antimony and ſuper-oxigenated muriate of pot-aſh, upon a ſteel anvil, it fulminates with a loud report, emitting a flame as brilliant and rapid as lightning.

71. Formerly, two antimoniated vitreous compounds were prepared in the pharmaceutical laboratories; the one, known by the name of *Ruby of Antimony*, or *Opaline Magneſia*, was produced by the fuſion of equal parts of decrepitated muriate of ſoda, nitrate of pot-aſh, and ſulphuret of antimony; in this manner, a vitriform maſs was obtained, of a light brown colour, brilliant and covered with a white ſcoria. The other preparation, very improperly termed medicinal regulus, was prepared by the fuſion of a mixture of fifteen parts of ſulphuret of antimony, twelve parts of decrepitated muriate of ſoda, and three parts of tartar. In this manner was produced a black glaſs, ſhining, opaque, without the metallic aſpect, and very denſe. Theſe two compounds are ſpecies of liver of antimony, which proceed from a decompoſition of the muriate of ſoda, or of nitrate of pot-aſh, and have not yet been examined.

72. The reciprocal action of antimony, of its ſulphuret and of its oxides upon the phoſphates, the fluates, the borates, and the carbonates has not been appreciated; we only know that the phoſphates and the borates, fuſed with the white oxide of antimony, become vitrified and aſſume the brown or the hyacinth colour, and that the carbonates heated with the ſulphuret of antimony loſe their carbonic acid, efferveſce at the moment when they combine with its ſulphur, and afterwards form anti-

moniated ſulphurets, which contain the alkalis in the cauſtic ſtate.

73. Scheele has found in the combined action of the ſalts and of the acids a very ſimple and very commodious proceſs, for procuring abundantly and eaſily that ſpecies of oxide of antimony, which water always ſeparates from its muriatic ſolution, and which is known by the name of Powder of Algaroth, as I ſhall ſhow in the article concerning mercury. In this proceſs, a liver of antimony is prepared by treating by detonation a mixture of one part of ſulphuret of antimony, and a part and a half of nitre. One part of this compound is mixed with three parts of water, and nearly one part of ſulphuric acid, to which muriate of ſoda is added in the ſame proportion as this acid. This mixture, placed in a matraſs, is left to digeſt for twelve hours upon a ſand-bath, the veſſel being conſtantly agitated. When the ſolution has been made, and has cooled, it is paſſed through a piece of linen; the undiſſolved reſidue is treated again with the ſame ſolvent, diluted ſulphuric acid, and muriate of ſoda, and the liquor, after having been filtrated, is mixed with the firſt. When this liquor is poured into boiling water, a precipitate is formed of white oxide of antimony, or *powder of Algaroth*, which is to be waſhed in a large quantity of water, and dried for uſe. In this operation, the muriatic acid, diſengaged by the ſulphuric, diſſolves the oxide contained

in the *liver of antimony*, and the water that is added precipitates it.

K. *Uſes.*

74. It has been ſeen elſewhere, that the numerous labours of the chemiſts upon the ſulphuret of antimony were undertaken with the view to prepare medicines of a great degree of activity, and exempt from the inconveniences that were apprehended in this ſubſtance. Of all the preparations that have been ſucceſſively invented, there is ſcarce any which is ſtill employed for medical uſe, except the *kermes*, the *antimonium diaphoreticum*, the *ſulphur auratum*, and the *glaſs of antimony*. The uſe of antimony in pills, or as a medical cup has been laid aſide, becauſe their effects have been found to be very variable and uncertain. Several other preparations which ſhall be elſewhere mentioned are alſo uſed as medicines. In general, the antimonials are emetic, purgative, ſudorific, and pectoral. Many phyſicians doubt the efficacy of the ſulphur of antimony ſuſpended in ptiſans and decoctions, to which it was long believed that it communicated a ſudorific and attenuating property. The powder of Chevalleraye, or the oxide of antimony by nitre, treated ſeven ſucceſſive times with this ſalt, and lixiviated each time, has long ſince been laid aſide, as being deſtitute of any virtues, and too much oxidated; for it is at preſent ſufficiently aſcer-

tained, that antimony in its metallic ſtate has no virtues, that it aſſumes more or leſs powerful properties when it is combined with a certain proportion of oxigen, and that it loſes them again when it contains a very large quantity. The effects of antimonial medicines are very much exalted, either by the medium ſtate of oxidation into the brown, orange, or yellow colour, or by the combination of theſe oxides with ſulphur and ſulphurated hidrogen, as is ſeen in the ſulphurated and hidro-ſulphurated oxides of antimony, which are known by the appellations of *kermes* and *ſulphur auratum*, and which are the moſt active preparations of this metal.

75. Antimony is uſed in many of the arts: it is the baſe of the alloy which is employed for caſting printing-types, to which it communicates hardneſs. It is often made to enter, with lead and tin, into rigid hard alloys, which are very uſeful for a variety of purpoſes. The oxide of antimony is uſed in the fabrication of coloured glaſs, enamels, the glazing and painting upon porcelain; it is the baſis of the yellow, browniſh, and orange colours, and ſhades more or leſs approaching to that of the amethyſt. It is mixed with ſeveral other different oxides, in order to produce a great variety of colours, the effects of which have been obſerved, but their cauſes not yet ſufficiently appreciated.

ARTICLE XIII.

Of Tellurium.

A. *Hiſtory.*

1. MR. KLAPROTH of Berlin, to whom we owe the diſcovery of Titanium and Uranium, has given the Latin name of *Tellurium*, which I render (in French) by the word *Tellure*, to a brittle metal which he diſcovered in the beginning of the ſixth year of the Republic, (end of the year 1797,) and made known to the ſcientific world, at the public ſitting of the academy of Berlin, in Nivoſe of the ſame year, (January 25, 1798). This appellation was adopted in conſequence of thoſe which he had given to the two metals already mentioned. Like thoſe, it is borrowed from fabulous mythology. It were to have been wiſhed that this celebrated Pruſſian chemiſt had derived it from ſome characteriſtic property of this new metal, as we have done in adopting the appellation of chrome for the metal diſcovered by Vauquelin.

2. He made this important diſcovery in examining the gold ore of Muriahilf, of the mountains of Fatzbay in Tranſylvania, known by the name of the white ore of gold, *aurum paradoxum, aurum problematicum.* Already in the year 1782, Mr. Muller of Reichenſtein, had ſuſpected the exiſtence of a peculiar metal in this ore. Bergman, to whom this minera-

logiſt had ſent a ſpecimen of the ore, had not been able, on account of the ſmall quantity of it with which he was provided, to decide whether it was really a peculiar metal, or merely antimony, with which it has ſome remarkable ſimilarities; but he was more inclined to the former opinion.

3. After having treated this ore with the nitro-muriatic acid, Mr. Klaproth precipitated and re-diſſolved it by means of pot-aſh, and afterwards ſeparated it again with muriatic acid. The ſubſtance ſeparated from the alkali, and depoſited by the laſt-mentioned acid, having been heated with an oil, yielded the metal which he has termed Tellurium. This diſcovery has not yet been ſince confirmed by other chemiſts, as the minerals in which Mr. Klaproth found the Tellurium are yet very rare; however, the talents and accuracy of this illuſtrious chemiſt are ſufficiently known to authorize our confidence in the facts which he announces.

B. *Phyſical Properties.*

4. TELLURIUM is of a white colour, approaching to a lead-grey, and poſſeſſes a conſiderable degree of metallic luſtre. It is very brittle, and eaſily reduced into powder. Its texture is lamellated like that of antimony. By ſlow refrigeration it aſſumes a cryſtalline and regular form, eſpecially at its ſurface. Its ſpecific gravity is 6,115.

5. It ought to be ranked amongſt the metals of the greateſt fuſibility. It is not known in what degree it poſſeſſes the powers of conducting either caloric or electricity. When fuſed in cloſe veſſels, it ſoon boils up, and is volatilized, ſo that its globules attach themſelves to the roof of the retort: in this property it ſeems to reſemble mercury; at leaſt, next to that liquid metal, it ſeems to be the moſt volatile of all metals.

C. *Natural Hiſtory.*

6. It appears that we may at preſent diſtinguiſh four ores of tellure; the firſt is that in which Mr. Klaproth firſt diſcovered this new metal; namely, the white gold ore of Fatzbay, which has already been mentioned; it reſults from the combination of this metal with iron and gold. This *aurum paradoxum* is of a greyiſh-white colour, in cryſtalline grains collected together in a gangue of quartz and marl.

7. The ſecond ore is the *graphic gold* of Offenbaya, formed of tellurium, gold, and ſilver; its colour is a yellowiſh white and it is compoſed of compreſſed priſmatic cryſtals, reſembling the Turkiſh method of writing, in their reſpective poſitions. It is found in a greyiſh-blue argillaceous porphyry, implanted in grey quartz.

8. The third is the mineral known by the name of the yellow gold ore of Nagyag in Tranſylvania. It is more complicated in its compoſition; beſides tellurium, it contains gold, lead, ſilver, and ſulphur. Its colour is a ſilvery white, verging a little towards a braſs-yellow; it is compact, and intermingled with quartz and brown ſpar: it is alſo found in broad radii that have a lamellated fracture.

9. Laſtly, the fourth is another variety of the ſame mineral of Nagyag, denominated the *foliated grey ore of gold*; it appears to differ from the preceding only in the proportions of its principles, and by its containing a ſmall quantity of copper, according to the analyſis given by Mr. Klaproth. The colour of this ore is a deep lead-grey, verging towards an iron-black; it forms ſmall leaves united into thin plates, of an oblong hexahedral form, partly accumulated, ſo as to form cells, of a moderate degree of luſtre, flexible, and frequently curved. It is found in a bed of quartz, mixed with reddiſh manganeſe, which it penetrates in every direction.

10. It is probable that there exiſt ſome more unknown ores of tellurium, and that it will be particularly found in thoſe of gold.

D. *Docimaſy.*

11. I HAVE ſhown in what manner Mr. Klaproth arrived at the diſcovery of this new metal; but I have not accurately deſcribed the

aſſay of the ore of Fatzbay, by means of which he not only extracted the tellurium, but alſo ſeparated it from other ſubſtances that were combined with it, ſo as to make an exact analyſis of the mineral in which the tellurium is contained. It is neceſſary that I ſhould here deſcribe his proceſs, in order that it may be repeated by thoſe chemiſts who may have ſimilar ores in their poſſeſſion.

12. By ſlightly heating the ore with ſix parts of muriatic acid, and ſubſequently boiling it, after having added to it three parts of nitric acid, a conſiderable efferveſcence took place, and the whole was diſſolved. The ſolution diluted with a little diſtilled water, was mixed with a ſufficient quantity of cauſtic ley of pot-aſh to diſſolve the precipitate; nothing more remained than a brown flaky depoſit, conſiſting of oxide of gold and oxide of iron. The alkaline ſolution of oxide of tellurium was mixed with muriatic acid, ſo as to ſaturate the pot-aſh, and a very heavy white powder was depoſited in great abundance. It was by reducing this powder to the conſiſtence of a paſte with a fat oil, and afterwards heating it to redneſs in a glaſs retort, that Mr. Klaproth obtained the tellurium reduced, partly fuſed and cryſtallized at its ſurface at the bottom of the retort, and partly ſublimed and fixed in drops at the curvature of the veſſel.

13. The ſame experiment, performed upon the three other ores, the graphic gold, and the two of Nagyag, and combined with the pro-

ceſſes for ſeparating the different ſubſtances united with the tellurium in them, gave Mr. Klaproth the following reſults relative to the docimaſy of theſe ores.

A. The Ore of Fatzbay, or the *Aurum Problematicum* contains, acording to this analyſis - - - - -	Tellurium - -	925,5
	Iron - - - - -	72,0
	Gold - - - - -	2,5
		1000,0
B. The graphic gold of Offenbaya - - - - - -	Tellurium - - - -	60
	Gold - - - - -	30
	Silver - - - - -	10
		100
C. The yellow gold ore of Nagyag - - - - - - -	Tellurium - -	45
	Gold - - - - -	27
	Lead - - - - -	19,5
	Silver - - - - -	8,5
	Sulphur, an atom	
		100.0
D. The foliated grey ore of gold of Nagyag - - -	Lead - - - - -	50
	Tellurium - - - -	33
	Gold - - - - -	8,5
	Sulphur - - - -	7,5
	Silver and Copper	1

14. Nothing can yet be ſaid concerning the metallurgy of the ores of tellurium, as no one has hitherto endeavoured to extract this metal from them, and they have only been treated with the view to ſeparate the gold.

E. *Oxi-*

E. *Oxidability by the Air.*

15. When we heat tellurium with the blowpipe upon a piece of charcoal, it burns, after having been fuſed, with a pretty lively flame, of a blue colour, edged with a greeniſh tinge; it is entirely volatilized in the form of a ſmoke of a whitiſh grey colour, which diffuſes a peculiar fetid odour, that Mr. Klaproth compares to that of radiſhes.

16. The oxide of tellurium appears to be extremely fuſible, for nothing more is required than to heat it in a retort, in order to obtain from it a maſs of a ſtraw-yellow, which exhibits a radiated texture when it has cooled. It is reduced rapidly, and with a kind of exploſion reſembling a detonation, when it is heated in a hole made in charcoal, and ſurrounded with this ſubſtance.

F. *Combination with the Combuſtible Bodies.*

17. Mr. Klaproth has only pointed out the combinations of tellurium with ſulphur and with mercury; and the latter combination is merely indicated by its eaſily forming an amalgam. It appears to form with ſulphur, and undoubtedly by fuſion, a grey ſulphuret of lead of a radiated texture and readily cryſtallizable.

G. *Action upon Water and the Oxides.*

18. We find no information in the memoir of the chemiſt of Berlin concerning the habitudes of tellurium with reſpect to water, and the metallic oxides. However, amongſt the facts which he has deſcribed, there are ſeveral which prove that its attraction for oxigen is but weak: hence we may preſume that it cannot exert any action upon water, nor a great number of metallic oxides, ſince its own is ſo eaſy to be decompoſed, as I have already mentioned, and as I ſhall further ſhow in conſidering the reſt of its properties of which I ſhall have occaſion to treat.

H. *Action upon the Acids.*

19. Tellurium ſeems to be very ſuſceptible of being attacked by moſt of the acids: the information which its diſcoverer has given us reſpecting its union with theſe burned ſubſtances, is the following. One part of Tellurium mixed in the cold with one hundred parts of concentrated ſulphuric acid, in a cloſe veſſel, cauſes this acid to aſſume a fine crimſon colour. On adding water, drop by drop to this ſolution, the colour diſappears, and the ſmall quantity of diſſolved metal is depoſited in the form of black flakes. The ſame ſolution, when heated, equally loſes its colour, and gradually precipi-

tates the oxide of tellurium in a white powder. When on the contrary we employ ſulphuric acid diluted with two or three parts of water, and with the addition of a ſmall quantity of nitric acid, this mixed acid diſſolves a pretty conſiderable quantity of tellurium; the ſolution is clear and colourleſs, and is not decompoſed by a larger quantity of water. The form and other properties of this ſulphate of tellurium are not known.

20. The nitric acid eaſily diſſolves tellurium; this ſolution is white and conſiderably tranſparent. When concentrated, it ſpontaneouſly yields ſmall cryſtals of a white colour, light, and in the form of needles aggregated in dendritic figures. The nitro-muriatic acid alſo diſſolves it very eaſily; a large quantity of water added to this nitro-muriatic ſolution, precipitates the oxide of tellurium in the form of a white powder, which is ſoluble in the muriatic acid. Mr. Klaproth has given no account of the action of this laſt acid upon the metallic tellurium.

21. All the pure alkalis precipitate the acid ſolutions of tellurium in a white oxide, ſoluble in the acids; an exceſs of alkali re-diſſolves the whole of the precipitate; it is ſeparated again by means of the acids, employed with caution. If, inſtead of pure alkali, we make uſe of an alkaline carbonate, we likewiſe obtain a precipitate, but one which is much leſs ſoluble in an exceſs of the precipitant.

22. The alkaline ſulphurets, added to the acid ſolutions of tellurium, form in it a precipitate of a brown or blackiſh colour, accordingly as the metal in the ſolution is more or leſs abundantly oxigenated. Sometimes this precipitate reſembles the hidro-ſulphurated brown or orange-coloured oxides of antimony, or the *Kermes* and the *Sulphur Auratum*; this is one of the analogies which ſubſiſt between tellurium and antimony. The ſulphurated or hidro-ſulphurated oxide of tellurium thus formed, when laid upon a red-hot piece of charcoal, burns with a ſmall blue flame, and is volatilized into a white ſmoke.

23. The infuſion of galls, poured into the acid ſolutions of tellurium, cauſes them to depoſit a flaky precipitate, of a dull yellow colour. The pruſſiate of pot-aſh, in a ſtate of conſiderable purity, does not precipitate them; in this very remarkable property tellurium reſembles antimony, gold, and platina; beſides theſe four, there is no other metal which is not precipitated, or the acid ſolutions of which are not decompoſed, by the pruſſiate of pot-aſh.

24. Zinc and iron ſeparate tellurium from its acid ſolutions, in the metallic ſtate, and in the form of ſmall black flakes, fuſible into a metallic button upon burning charcoal, and which reſume their luſtre by mere friction. Antimony preſents the ſame precipitation with the liquid nitrate and ſulphate of tellurium, a convincing proof that theſe two metals are really very dif-

ferent

ferent from each other. Tin poſſeſſes the ſame property with reſpect to the new metal; its muriatic ſolution, mixed with that of tellurium in the ſame acid, gives a black metallic precipitate.

25. The oxides of tellurium, precipitated from its acid ſolutions by means of the alkalis, or from its alkaline ſolutions by means of the acids, are very eaſily reducible by charcoal, and in this reduction they loſe their oxigen ſo quickly, that they exhibit, during the operation, a motion and rapidity that may be compared with a detonation. It is ſufficient to mix them with fatty ſubſtances, and heat them in a retort, in order to obtain them in the ſtate of metallic tellurium, partly fuſed and collected in a button at the bottom of the veſſel, and partly ſublimed into ſolid drops at its curvature.

I. *Action upon the Baſes and the Salts.*

26. Mr. Klaproth has ſaid nothing concerning the action of tellurium upon the earthy and alkaline baſes. It only reſults from his firſt experiments, that the oxide of this metal is eaſily ſoluble in the liquid cauſtic alkalis. The ſpontaneous fuſibility of this oxide authorizes us to believe, that it may enter with the earths into vitrification, and that it is capable of imparting to the glaſs a ſtraw-yellow colour.

27. Its eaſy combuſtibility affords equal reaſon to believe that it may be ſpeedily burned by the nitrate of pot-aſh, and by the ſuper-oxigenated muriate of the ſame baſe. There is no doubt, that when mixed in the ſtate of powder with the laſt mentioned ſalt, it will inflame and fulminate by percuſſion, as is the caſe with ſo many other metallic ſubſtances.

K. *Uſes.*

28. NOTHING can be yet ſaid concerning the uſes of a metal ſo recently diſcovered, and which appears hitherto to be ſo ſcarce. But ſhould it be found in other ores beſides thoſe of Tranſylvania, as there is reaſon to hope may be the caſe, it cannot be doubted that it may become of great utility in the arts, as appears from its extreme fuſibility and its ſlight adheſion with oxigen. Before I conclude this article, I cannot refrain from remarking how important an acquiſition ſcience has made, in the diſcovery of a metal, which ſeems to hold a middle rank between antimony and mercury, which is very eaſy to be fuſed, and which is obtained with ſuch facility from its ores; and how much ſuperior advantages its diſcovery promiſes to mankind, than thoſe of uranium and titanium, which we owe to the ſame chemiſt, but the treatment of which is ſo difficult, and their reductibility and fuſibility ſo limited.

ARTICLE XIV.

Of Mercury.

A. *Hiſtory.*

1. MERCURY, which, like many other metals, appears to have received its name from the planet with which it was compared by the Perſians, on account of its nature which was ſuppoſed to approach to that of gold, as this planet is neareſt to the ſun, has been known ſince the moſt remote ages of antiquity. From a compariſon of its properties with thoſe of ſilver, it was long ago termed *quick-ſilver, hydrargyrum.* In the ſpecies of hieroglyphics that were formerly employed for repreſenting bodies, mercury was repreſented by the combined ſigns of the ſun and moon, or of gold and ſilver, linked together and ſupported upon a croſs. The ſign of the gold was placed in the middle, and over it was ſeen that of the ſilver, which ſeemed to cover and colour the firſt; the croſs at the bottom ſignified that it poſſeſſed acrimony. Its uſe in the arts bears date from a very remote antiquity.

2. The alchemiſts have laboured much upon this metal. They conſidered it as very much reſembling gold and ſilver, and differing but very little from them; they imagined that it wanted but very little to become either the

one or the other, and they always hoped to diſcover the means of tranſmuting it into theſe metals. Some of them have even affirmed, that they had ſucceeded in effecting this tranſmutation. Theſe adepts agree with each other, that it is much more eaſy to convert it into ſilver than into gold. According to them, in order to convert it into ſilver, nothing more is required than to fix it. It was, therefore, in this fixation of mercury that they made all the art of their opus magnum, all the marvellous of their ſcience to conſiſt; this was the grand object of their attention, and the ſcope of all their wiſhes. All theſe pretenſions, however, are not ſupported by a ſingle well-atteſted fact; and the more we advance in the ſtudy of the properties of mercury, the more differences we find between it and the metals to which it has been ſuppoſed to approach the neareſt.

3. To theſe opinions, exaggerated and hypothetical as every thing belonging to the pretended art of alchemy is, the adepts added another ſtill more abſurd and ridiculous. By tormenting this metal in a thouſand ways, and conſidering it as the firſt and moſt important object of their reſearches, they were led to ſuch a pitch of extravagance, as to pretend that mercury was a principle of all beings, that it was one of the elements of Nature, which ſhe employed in the compoſition of many ſubſtances; that it was contained in all metals; hence they diſtinguiſhed two ſpecies of mer-

cury, that of the philoſophers, the principle of a great number of ſubſtances, which they pretended excluſively to know how to extract, and to poſſeſs; and the other, the common mercury, the mercury of all the world, that which is employed in the arts. Hence aroſe the hypotheſis of the *mercurial principle*, or of the *mercurial earth*, which Becher has diſtinguiſhed from the other earths, and which he ſuppoſed to exiſt in all ſubſtances that are at the ſame time ponderous and volatile. It will readily be believed, that no chemiſt has been able to demonſtrate this pretended earth.

4. Who would imagine that theſe extravagant notions and hypotheſes, deſtitute of all foundation, have, nevertheleſs, given birth to the chemical hiſtory of mercury? who ſhould conceive that it is to the toilſome reſearches of theſe unfortunate and indefatigable labourers in an art which never exiſted, that we owe the firſt and moſt arduous diſcoveries that have been made upon this beautiful metal? Nothing, however, can be better demonſtrated than that ſuch is really the caſe. It is to the alchemiſt that we owe our knowledge of the volatility of mercury, the art of knowing and obtaining it in a ſtate of purity, the knowledge of its unalterability in cloſe veſſels, of its oxidation by fire and air, of the proceſſes required in order to make it burn by preventing its diffuſing itſelf in the air, of its principal combinations, of the immenſe variety of colours of its preci-

pitates, of its ſalts, and their different ſtates, of its action upon metals, of its union with ſulphur, and in a word, of its principal properties.

5. The chemical phyſicians, on their part, always influenced by the idea of appropriating natural bodies to the treatment of diſeaſes, of diminiſhing the acrimony of thoſe that were too active, of directing their effects, &c. have performed a multiplicity of operations upon mercury and its pharmaceutical preparations. They have diſcovered in it a great number of properties, have made it enter into a variety of different compoſitions, and have greatly advanced our knowledge of the attractions to which it owes all the modifications it is capable of receiving.

6. The moſt celebrated philoſophers, and the moſt able chemiſts, have all ſucceſſively occupied themſelves with this metal; they have endeavoured to aſcertain all its properties with more or leſs preciſion; and the uſe which has been made of it ſince the end of the laſt century, or ſince the time of Boyle, in the conſtruction of a great number of philoſophical inſtruments, has afforded frequent occaſion for inveſtigating and examining its different characters. It is in this manner that its weight, its phoſphoreſcence, its dilatability, its volatility, its alterability, its mobility, &c. have been ſucceſſively aſcertained.

7. It is eaſily conceived, that ſo intereſting a metallic ſubſtance muſt have engaged all chemiſts to make it ſucceſſively the object of their reſearches. There is not one of them, during a century paſt, who has not laboured upon the combinations of mercury, and it would be neceſſary to name them all, the one after the other, in order to give a catalogue of the authors who have treated of this metal. Amongſt theſe able men, we muſt, however, diſtinguiſh Boerhaave, who combined with the ſagacity of the experienced phyſician the indefatigable patience of the chemiſt, and to whom we owe a ſeries of fine experiments and important reſults reſpecting mercury. From the profeſſor of Leyden down to Bergman, who has written an intereſting diſſertation concerning corroſive ſublimate, the greater number of chemiſts have each of them added ſome facts to the ſeries of thoſe which Boerhaave had collected or diſcovered.

8. The application of the pneumatic chemiſtry has connected together all the known facts relative to the chemical properties of mercury; it has given riſe to the diſcovery of a conſiderable number of new ones; it has elucidated a great number of facts which before could not be explained; it has drawn from oblivion ſeveral which were neglected, or in a manner abandoned; it has diſſipated all the obſcurity, ambiguity, or uncertainty that remained in the enunciation of its properties; it has

conducted the French chemiſts to ſeveral important diſcoveries, ſuch as the mutual differences between the greater part of the metallic or mercurial ſalts, the comparative ſtate of the different oxides of mercury, the action of each oxide upon this metal or its oxides, the formation of ſeveral triple ſalts, the cauſe of the energy and cauſticity of the mercurial ſalts or oxides, the ſpontaneous reduction of theſe oxides, their decompoſition by ſome of the metals, the nature and characters of ſeveral precipitates, the different ſtate of ſome of its ſolutions, the extinction of mercury in a number of ſubſtances, which had always been conſidered as a ſimple diviſion, but which, in reality, is a true oxidation, &c. &c. By the aggregate of theſe diſcoveries, as alſo by the re-union, the approximation, and in ſome meaſure the renovation of all the ancient reſults of experiments performed prior to the birth of the pneumatic theory, the hiſtory of mercury has not only been rendered much more accurate and much more perſpicuous than it was before; but it has alſo acquired a method, a regular and ſyſtematic form, which renders it a kind of epitome of all the fundamental points of this theory, as I have already ſhown with reſpect to various other ſubſtances, no leſs important than that of which we here treat. The latter conſideration makes me think it incumbent upon me to deſcribe with much care, at full length, and with all the requiſite minuteneſs of detail, the properties of mercury, which, beſides is one of the moſt uſeful of metallic ſubſtances for medicinal purpoſes, for the arts, and for all thoſe branches of knowledge, the improvement of which tends to accelerate that of human reaſon in general.

B. *Phyſical Properties.*

9. **Mercury**, a metal which is always fluid when in a pure ſtate, at the ſurface and in the interior of the globe, is one of the moſt brilliant and ſhining of all known metals; when its ſurface is ſufficiently clear, it forms a very fine mirror. Its colour is as beautiful as that of ſilver, with which it has always been compared. After platina and gold, it is conſidered as the heavieſt of all known bodies. Its ſpecific weight is 13,568, taking water at 1,000. Citizen Guyton, however, places the tungſten metal above it, to which he aſcribes a weight equal to 17,600. Muſchenbroeck has reckoned that of mercury from 13,500 to 14,110, according to its different degrees of purity. Formerly alſo authors were very particular in obſerving, that all the moſt ponderous ſubſtances ſwam upon its ſurface, whilſt gold alone ſunk in it; at the preſent day we have to add to this, platina and tungſten.

10. The diviſibility of this liquid metal into an immenſe number of ſmall globules, by means of preſſure, has attracted the attention

of all the natural philoſophers who have occupied themſelves with it. Boyle, after having reduced it to a ſtate of extreme diviſion by diſtillation, receiving it into a large capital of glaſs, the inner ſurface of which it covered with an innumerable quantity of globules, diſcovered them to be as many ſmall ſpheres or mirrors, which, collected upon the glaſs, gave it a very bright white colour. The manner in which it paſſes, by preſſure, through the pores of prepared ſkins, and its falling down in a ſilver-ſhower, alſo prove its extreme diviſibility, which is likewiſe apparent from the ill effects which its vapour produces upon perſons who remain for ſome time expoſed to it. Liebknecht tells us that by ſtriking a globule of mercury ſix lines in diameter, he divided it into ſuch extremely minute globules, that he could perceive 100,000,000 of them with the aid of the microſcope.

11. It is not ſurpriſing that a metal which is always fluid, of great ponderoſity, of perfect brilliancy, and at the ſame time ſingularly volatile, ſo uſeful in a great number of the arts, ſo remarkable, and ſo different from all other metals in its combinations and chemical properties, has been conſidered as a kind of independent body, an anomalous ſubſtance, and even as a ſort of principle, capable of communicating to other bodies a part of its characteriſtic properties. It was the water which does not wet, *aqua non madefaciens manus,* of ſome authors,

thors, the movable ſilver, *argentum mobile*, of ſome of the ancients; appellations of which the word *quick-ſilver* is probably a tranſlation. It was ſuppoſed to be a powerful agent in the operations of nature, as it appeared to be ſo important an agent in the operations of art.

12. Nevertheleſs, too much ſtreſs has been laid, in the ſingular notions and the exaggerated pretenſions of the alchemiſts, upon the fluidity of mercury, as upon an indelible property. Boerhaave ſtill aſſerted in his Elements of Chemiſtry, that mercury could not be rendered ſolid by any degree of cold, though he admits a condenſation of $\frac{1}{269}$ of its primitive volume; a circumſtance which cannot take place in its real congelation. This aſſertion of Boerhaave and other philoſophers who have followed him, was proved to be falſe in the year 1759; in which year the academicians of Peterſburg, availing themſelves of an intenſe degree of natural cold, augmented it ſtill further by a mixture of ſnow and fuming nitrous acid: the mercurial thermometer which they uſed deſcended to 213 degrees of De Liſle's ſcale, which correſponds with 46—0 of that of Reaumur. As the mercury did not deſcend any lower, but ſeemed ſtationary, the academicians broke the glaſs bulb of their inſtrument, in which they found congealed mercury, that formed a ſolid ſubſtance ſuſceptible of being extended by the hammer. They thus diſcovered that mercury might become ſolid, and that in this

ſtate it poſſeſſed a certain degree of ductility. They remarked that at every ſtroke of the hammer, the preſſure, developing the caloric in the interior of the metal, fuſed it, and that it ran into globules.

13. This firſt experiment was, in ſome meaſure, nothing more than a hint to philoſophers concerning a property unknown, and till then even denied, in mercury; it has ſince been often repeated, and of late it has become as eaſy and ſimple an experiment as moſt of thoſe that are made in chemiſtry. In the year 1772, Pallas cauſed mercury to congeal, at Kraſnejark, by a natural cold of —55½ deg. of Fahrenheit's ſcale; it was obſerved, that it then reſembled ſoft tin; that it could be flattened; that it broke eaſily, and that its fragments, when brought into contact, were glued or ſoldered together, as happens in all other ſoftened metals: however, it is evident, that he did not obtain its real converſion into a ſolid, or complete concretion, as the mercury was ſtill ſoft and only in a ſtate of ſemi-congelation. In the year 1775, Mr. Hutchius obſerved the ſame congelation at Albany-fort, and Mr. Bicker at Rotterdam, in 1776, at 56 deg. below 0. In the year 1783, the congelation of mercury was effected in England with a leſs degree of cold; and Mr. Cavendiſh has proved 31½—0 of Reaumur's thermometer to be the real degree at which it took place.

14. In the Polytechnic ſchool, within a few days after its inſtallation, on the 18 Nivoſe of the 3d year of the Republic, (Jan. 5, 1795), the experiment of the congelation of mercury was performed by refrigerating mixtures of ice and muriate of ſoda, of ice and nitric acid. The temperature of the atmoſphere being 9-0, a thermometer with alcohol deſcended by the refrigeration of theſe mixtures, uſed alternately as baths, to 31—0. Mercury, in a ſtate of conſiderable purity, incloſed in bulbs of thin glaſs, and immerſed in this cold of 31—0, paſſed into the ſolid ſtate. At the moment when the congelation took place, the perſon who held the tube of glaſs in his hand perceived a ſlight concuſſion, produced by a ſudden retreat of the fixed metal; a ſpecies of phenomenon which is alſo perceived very ſenſibly when phoſphorus becomes fixed. A manifeſt cryſtallization into very ſmall octahedrons was obſerved in the mercury. Pelletier having placed this ſolidified mercury in the hollow of his hand, experienced a painful ſenſation, which he compared to a burn. The part of the ſkin which had remained for a certain time in contact with this ſubſtance, exhibited a white ſpot, which afterwards became red, and remained very viſible during ſeveral days ſubſequent to the experiment. This mercury, being beat upon an anvil of ſteel, and with a hammer cooled to 17, was very much flattened, and ſhowed a ſufficiently marked ductility.

15. The chemiſts of the polytechnic ſchool wiſhed, moreover, to aſcertain the proportion between the capacity of ſolid and that of liquid mercury, and how much caloric it abſorbed in order to become liquefied: this they did, as far as was within their power, by mixing, in a hollow piece of charcoal, ſolid mercury at 31—0 with liquid mercury at 8+0. The reſult of temperature which they obtained led them to conclude, if not with perfect accuracy, at leaſt, in a manner approximating to it, that ſolid mercury abſorbed, in order to its fuſion, a quantity of caloric, which, if transferred to the ſame proportion of liquid mercury, would raiſe its temperature by nearly 69 degrees, that is to ſay, would heat it to near 38+0 Reaumur, that it was conſequently much leſs dilatable by a given porportion of caloric in its ſolid than in its liquid ſtate.

16. This reſult, which is not yet rigorouſly exact, except as conſidered in a general point of view, coincides with a ſingular property which has been very frequently obſerved in mercury, namely, that at the moment of its congelation, the mercury ſuddenly contracts in a conſiderable degree, which is the cauſe of the ſhock or concuſſion that is felt in holding the veſſels in which this congelation is effected. This phenomenon has even deceived ſeveral obſervers, who, in conſidering the converſion of mercury into a ſolid, have judged of the reduction of temperature at which it took

place, by adopting as a meaſure of this reduction, the point to which this metal had deſcended in the thermometer at the very moment of its congelation, a point, which, beſides the product of the congelation, exhibits alſo the effect of its ſudden ſhrinking or inſtantaneous contraction.

17. It has been concluded from the flattening which ſolidified mercury experiences from the percuſſion of the hammer, that this metal poſſeſſes a certain degree of ductility, and it is on this account that I have placed it together with zinc in the third diviſion of the metals, which have the character of ſemi-ductility. But it is very evident, that this property is extremely limited, that it cannot even be aſcertained without many difficulties, and that it is as yet far from having been ſufficiently appreciated. The precaution has not even been uſed, except in the laſt mentioned experiment, which, however, could not be carried far enough, of employing, for the purpoſe of trying the malleability of mercury, inſtruments cooled to that lowneſs of temperature, which alone can retain it in its ſolid ſtate: it has, therefore, been ſpeedily liquefied, and almoſt at the firſt ſtrokes applied to it with the hammer, eſpecially in the firſt trials; for in thoſe of the polytechnic ſchool, the ſteel anvil and the hammer having been cooled to 17—0, the ſolid ball of mercury received ſeveral ſtrokes without either cracking or being fuſed; and it was only in the ſtate

of a flattened ball that Citizen Pelletier placed, and held it for ſometime in the hollow of his hand. We therefore do not know either the tenacity, the hardneſs, or the elaſticity of mercury; we only know that it poſſeſſes theſe properties in a very inferior degree.

18. Formerly much ſtreſs was laid upon the dryneſs of mercury, and its property of not wetting other ſubſtances; and it is certain, that this liquid metal does not attach itſelf to any of the bodies, that are wetted by water, the oils, or other liquids. But as this property of wetting manifeſtly depends upon the superficial attraction, which theſe liquids exert upon the bodies, it is evident, that the reaſon why mercury does not wet them, or does not attach itſelf to their ſurface, is becauſe it has little attraction for that ſurface: thus it really wets the ſubſtances with which it is able to unite, ſuch as the metals which it diſſolves, gold, ſilver, tin, lead, &c. and we cannot clear it from the ſurface of theſe, to which it adheres ſtrongly, except by the action of fire, in which they are not fuſible, or by chemical operations employed in order to deſtroy the real combination which it has formed with them.

19. As a metal always fuſed, always liquid at the temperature of our climates, mercury conſtantly affects the form of perfect globules when it is divided. When incloſed in a glaſs phial or tube, its ſurface is convex, which de-

pends upon the ſmall attraction which it has for the molecules of the glaſs; in fact, if we pour it into a veſſel or tube of ſome metal with which it is able to combine, inſtead of remaining convex, its ſurface becomes concave. As this round, curved, and convex ſurface may give riſe to ſome errors in barometrical obſervations, eſpecially in thoſe which are made with tubes of a fine bore, in which the elevation of the mercury ought to be an exact meaſure of the height of the places which we wiſh to determine, attempts have been made to obviate this ſource of error, by rendering the mercurial ſurface flat. Caſſebois ſucceeded by boiling the mercury for a long time in the barometrical tubes; by which means a ſurface almoſt perfectly horizontal was obtained, eſpecially in tubes of a wide bore. It appears that this horizontality is owing to the accurate ſeparation of the water which ſo frequently adheres to the mercury; for on introducing a few drops of this liquid the convexity of the ſurface inſtantaneouſly appears again, even though the quantity of water added, be ſo ſmall as not to be viſible.

20. The dilatability of mercury by the action of fire has not yet been very accurately determined; it is known to be a very good conductor of caloric, on which account it appears ſo cold to the hand when immerſed in it; and it is alſo owing to this conducting property, that a red-hot iron, when plunged into mercury, inſtantaneouſly loſes its redneſs, which

it would have retained for ſome time in the air, and even in water. Its dilation by caloric proceeds in a very uniform manner; and it is on this account that it is employed in the conſtruction of thermometers. When it is penetrated with a quantity of this principle, which has not yet been well aſcertained, but which is eſtimated at 140 degrees of Reaumur's thermometer, the mercury ſwells, is reduced to the ſtate of vapour and volatilized. When this experiment is performed in the air, the mercury preſently condenſes into a white ſmoke, which is capable of producing very injurious effects upon animals, and by which I have ſeen a man ſtruck with aſphyxia and paralyſis. If it be performed in cloſe veſſels, in ſuch a manner that the metal may ſpeedily become fixed and liquefied, this becomes a means of diſtillation, in which the habitudes of the volatile metal are the ſame as thoſe of every other diſtilled liquid. In this operation, which is often employed for the purpoſe of purifying the mercury, it is cuſtomary to adapt to the neck of the retort of iron or ſtone-ware which is uſed, a tube of linen, the extremity of which is immerſed in the water with which the receiver is filled. By means of this apparatus, the mercury is ſpeedily condenſed into the liquid form, and collected entire under the water, from which it is afterwards ſeparated by rubbing it with paper manufactured without ſize, drying it in a gentle heat, paſſing it through a ſkin, agitating it with very dry bread-crumb, bran, and other deſiccating means of a like nature. It is on account of this eaſy proceſs of diſtillation, that chemiſts have conſidered mercury as the moſt volatile of all metals.

21. In its reduction into vapour by means of fire, and its ſubſequent condenſation, mercury undergoes no alteration, if the veſſels uſed for this operation do not contain much air, if the apparatus be well cloſed, and if the mercurial vapour be ſpeedily condenſed by the contact of the cold water. The diſtillation is nothing more than a mere phyſical change of ſtate and form, effected in the mercury by the operation of fire, but it ſuffers no chemical alteration. Boerhaave had the patience to diſtil mercury 510 ſucceſſive times, without its ſuffering any alteration; he only imagined that he obſerved the metal had become more brilliant, ponderous and liquid than it was before. In fact, he obtained in this laborious experiment a ſmall quantity of grey powder, which appeared to him to be nothing more than mercury in a ſtate of extreme diviſion, and which required only to be triturated in a mortar in order to reſtore it to the ſtate of brilliant liquid mercury. We ſhall ſoon ſee that this was a ſmall quantity of the black oxide of this metal.

22. The alchemiſts conceived the expoſure of mercury to a high temperature to be a means of fixing it, or of depriving it of its fuſibility and volatility. For this purpoſe, ſeveral have

adviſed to incloſe it in thick, and very ſtrong veſſels, and in this manner to ſubject it to the action of a violent fire for a longer or ſhorter time; but the trials of this kind, that have been made have only proved that this metal is in the ſame predicament with all thoſe that are very expanſible and volatile, and that ſo far from being able to fix it, the effect of the fire is only to ſeparate its molecules from each other, to that degree, that in a ſtate of great expanſion, it forcibly breaks to pieces all the obſtacles that oppoſe this ſeparation. Hellot has related to the Academy of Sciences, that a perſon who wiſhed to fix mercury, introduced a certain quantity of it into a very well-ſoldered globe of iron, which he threw into the middle of a burning fire; but ſcarcely had it become red-hot, when the mercury burſt its receptacle with a loud report, and flew out of ſight. The ſame phenomenon occurred in the houſe of Geoffroy, the apothecary. An alchemiſt filled a ball of iron, which he incloſed in ſeveral other ſpheres, the laſt of which was ſecured by two very ſtrong hoops of iron placed croſs-wiſe, and threw the apparatus into a well-heated furnace in order to make it red-hot. After a certain period, the mercury burſt its encloſures with a loud noiſe, and the fragments of iron were thrown out with ſuch force, that they penetrated through walls and partitions like bomb-ſhells. The ſame experiment may be made without the ſame danger, by in-cloſing mercury in ſmall glaſs bottles, cloſed at their extremity by the heat of a lamp, and throwing theſe bottles into the midſt of the coals in a furnace placed in the open air. Theſe veſſels burſt with a report, and the mercury, having nothing to reſiſt its expanſion, flies into vapour.

23. Mercury is a very good conductor of electricity and of the animal property known by the name of Galvaniſm. Its electrical property is probably the cauſe of the phoſphoreſcence, and the conſiderably bright light which it emits, when it is agitated in a vacuum. This phenomenon was firſt obſerved in the year 1675, by Picard, a French geometrician, and member of the Academy of Sciences at Paris. This philoſopher, as he was carrying, during the night, in a dark place, a barometer that had been kept for ſeveral years in the obſervatory at Paris, obſerved that the mercury whilſt it was ſhaken in the tube, threw out luminous ſparks ſimilar to thoſe which are emitted by phoſphorus when expoſed to the air. This experiment was then repeated upon ſeveral other barometers, and only one was found, belonging to the celebrated aſtronomer Caſſini, which exhibited the ſame phenomenon. Mention was made of this property in a Treatiſe on Thermometers, Barometers, and Hygrometers, publiſhed at Paris in 1686, and at Amſterdam in 1708. The journals of the time alſo ſpeak of it; but twenty five years elapſed before its

examination was reſumed. The celebrated Bernouilli deſcribed in the year 1719, in a work profeſſedly written, *de mercurio lucente in vacuo*, or the manner of conſtructing luminous barometers, and propoſed a kind of clepſydra formed by this metal, flowing out of one tube, into another, and which during the night, ſhould indicate the hour, by the progreſſive and proportional diminution of the phoſphoreſcent column. S'Graveſande, Weidler, Haukeſbee, Homberg, Leibnitz, occupying themſelves with the ſame property, made more or leſs ingenious applications of it to luminous ſhowers, ſhining ſtreams, perpetual lamps, and compared this phoſphoreſcence with that of ſeveral other ſubſtances. Natural philoſophers, whilſt they confirmed the exiſtence of this property, ſoon diſcovered that it was not conſtant, that it varied, that it obtained only in hot and dry weather, and when the vacuum was perfect, and the mercury very pure, and that it even became gradually weaker in proportion to the diminution of all theſe conditions. It has been diſcovered that this phoſphoreſcence is an electrical phenomenon, which takes place only in conſequence of the friction of the mercury againſt the ſides of the tube, and that the mercury does not thereby ſuffer any ſenſible alteration.

24. A very peculiar ſmell and taſte are eaſily recognizable in mercury. To convince ourſelves that it poſſeſſes this property, nothing more

is neceſſary than to rub it for ſome time between the hands. The ſkin retains a conſiderable quantity of it, and it is ſufficiently diffuſed upon this organ for the olfactory nerves to be ſenſibly affected by it. Alſo when we paſs it over the tongue, a kind of acrid taſte, of an auſtere and metallic nature, is perceived, which, though analogous to that of ſeveral other metallic ſubſtances, has nevertheleſs a very diſtinct peculiar character, which one may learn to diſtinguiſh by habit. It is to this taſte that ſeveral phyſicians aſcribe the property which mercury is well known to poſſeſs, of killing ſmall inſects and worms; and it is to the ſame alſo that ſeveral attribute the effects of this metal in ſome cutaneous affections, the cauſe of which they have at the ſame time imagined they had diſcovered and explained, by ſuppoſing them to be produced by microſcopical inſects, though their exiſtence has never been accurately proved nor admitted by a great number of other perſons of the profeſſion.

C. *Natural Hiſtory.*

25. THERE are, as yet, only four well-known ſtates, or four well aſcertained ores of mercury in the interior of the earth: the firſt is native mercury, and the ſecond, the alloyed or amalgamated mercury; the third is the red ſulphuret of this metal, and the fourth the red muriate of mercury. In general, the ores of mercury

do not exiſt in nature in ſo great quantity, nor in ſuch large maſſes as thoſe of many other metals. They are a great ſource of wealth to the countries in which they are found; Spain, the Palatinate, Friuli, and ſome provinces of America, are the countries moſt favoured by nature with reſpect to this production, which is uſeful in a great number of the arts.

26. Native mercury, which has been termed virgin mercury, is found in the form of liquid globules, which are very eaſily recognized by their brilliancy and liquidity. It is commonly found in tender and friable earths and ſtones, and frequently interpoſed between the fiſſures and the cavities of its own orbs, eſpecially of its ſulphuret. It is ſeldom perfectly pure, and frequently contains ſome other metal with which it is alloyed; but when it is ſufficiently liquid, it is conſidered as pure or really native. At Ydria, and in Spain, and America, it is collected in the cavities and clefts of the rocks, into which it filtrates from all ſides. It is found liquid in argil at Almaden, and in the beds of chalk in Sicily. It is alſo found in the ores of ſilver and lead, and even mixed with the arſenious acid, or white arſenic.

27. Mercury, alloyed with other metals, exiſts more abundantly in the earth than native mercury, as the latter is rarely perfectly pure, and free from combination with any other metal. It is ſometimes in ſuperficial layers, extended over the ſurface of the gangue, and ſome-

times in ſolid grains which adhere to and line its cavities. The proportions of theſe two component metals vary greatly: frequently the proportion of mercury is ſo large that the amalgam is of the conſiſtence of a paſte, or ſemi-liquid. Bergman alſo ſpeaks of the native amalgam of gold and biſmuth. Some mineralogiſts aſſert that the amalgama of ſilver is found cryſtallized.

28. The red ſulphuret of mercury, known by the barbarous name of cinnabar, is an ore which varies in its tints, from the lively and brilliant red of vermillion, to a brown colour, ſimilar to that of ſeveral of the oxides of iron; its weight is pretty conſiderable: Muſchenbroeck has eſtimated it at 2,233; Mr. Kirwan computes it at 7,000. Sometimes it is in compact maſſes, ſometimes lamellated, compoſing part of veins; ſometimes it is in ſmall cryſtals of an indefinite figure, which Mr. Kirwan aſſerts to be cubes, and others, triangular priſms or pyramids, of a tranſparent ruby red; it is alſo found in powder, of a bright red colour, or in the form of an effloreſcence, which is termed native *vermilion*, or *flowers* of cinnabar. It has naturally no metallic luſtre; however, this luſtre is ſeen in the pieces recently broken, but it conſtantly diſappears to give place to the beautiful red colour which characterizes it when the broken piece is ſcraped. Citizen Haüy found that pieces of a perfectly lamellated texture, divided themſelves very neatly into layers,

parallel to the faces of a regular hexahedral priſm. According to the ſame mineralogiſt, the fracture of this ore is rugged in the direction of the baſes of the priſms juſt mentioned. He ſays, moreover, that he has never been induced to apply the theory of cryſtals to this ſpecies. We alſo find the ſulphuret of mercury mixed with ſtones or ſand, which are then red and very ponderous.

29. The fourth ſpecies of ore of this metal is the muriate of mercury. It is alſo termed *corneous mercury*, or mercury mineralized by the muriatic acid. Mr. Woulfe, an Engliſh chemiſt, was the firſt who diſcovered this mineral, at Obermuſchel, in Deux-Ponts; it is always mixed with a ſmall quantity of ſulphate of mercury. This native ſalt is brilliant, white, and lamellated; ſometimes it is found of a yellow or blackiſh colour, mixed with ſulphuret of mercury. The muriate of mercury exiſts in it in the ſuper-oxigenated ſtate.

30. To theſe four very diſtinct ſpecies ſeveral mineralogiſts have added ſome other ores of mercury, which have however not been generally acknowledged, or which manifeſtly belong to other metals. Citizen Sage has deſcribed a native oxide of mercury, which came from Ydria, in Friuli, of a brown-red colour, very mild, and of a granulated fracture mixed with ſome globules of liquid mercury. He aſſures us that this ore is reduced alone, and without any addition, into liquid mercury, by the

action of fire. Mr. Kirwan conſiders it as a native carbonate of mercury; it contains 0,91 of mercury. Baron Born alſo ſpeaks of a native oxide of mercury, in his mineralogical catalogue of the cabinet of Madamoiſelle de Raab. Cronſtedt, in his Mineralogy, has mentioned an ore of mercury, in which this metal is combined with ſulphur and copper; according to his deſcription, it is of a blackiſh-grey colour, brittle, and very ponderous; its fracture is vitreous; it decrepitates in the fire; it is found at Muſchel-Landſberg. Citizen Monnet, in his *Syſtême de Mineralogie,* has mentioned an ore, brought in the year 1768 from Dauphiné, by Montigny, in which he ſays he has found mercury, ſulphur, arſenic, cobalt, iron, and ſilver. But as this is only a grey and friable mixture, containing not more than $\frac{1}{100}$ of mercury, and $\frac{1}{200}$ of ſilver, it is evident that it ought not to be reckoned amongſt the ores of mercury. Finally, Baron Born has alſo ſpoken of an alkaline ſulphuret of mercury; but the modern mineralogiſts juſtly conſider its exiſtence as very doubtful. It is evident that none of theſe four laſt-mentioned ores ought to be added to thoſe which I have indicated as conſtant, ſufficiently diſtinct, and well marked, except the carbonate of mercury, or the native oxide, were its exiſtence well aſcertained; for that of Cronſtedt is nothing but a cupreous pyrites or ſulphuret of copper, containing mercury, probably diſſeminated in it, but not combined with it.

D. *Aſſay and Metallurgy.*

31. Before the time of Bergman, the aſſay of the ores of mercury, and eſpecially of the native ſulphuret of this metal, for this was almoſt the only one attended to, was an operation, either very imperfect, or very ſuperficial. In order to examine an ore containing mercury, it was mixed, in the ſtate of powder, with lime or alkali; and this mixture was thrown upon a hot brick, which was immediately covered with a bell-glaſs, in which the mercury was volatilized and condenſed, attaching itſelf in ſmall drops to its ſides. When this aſſay, which often was a ſufficient inducement for undertaking works upon a large ſcale, was not deemed ſatisfactory, on account of the price of this metal, and when it was wiſhed to aſcertain how much mercury this ore contained, or was able to yield, it was diſtilled with ſubſtances capable of retaining the ſulphur and diſengaging the mercury from it, ſuch as lime, the alkalis, and iron. Water was put into the receiver, a piece of linen was attached to the beak of the retort of ſtone-ware which was uſed; and after the operation, the mercury obtained was weighed; and the diminution of the weight which remained was alſo determined.

32. Inſtead of theſe defective operations, Bergman propoſed, in his Diſſertation on Hu-

mid Aſſaying, to ſubſtitute real analytical proceſſes. Native mercury is ſo frequently alloyed with foreign metals, that it is uſeful to determine their proportion ; for this purpoſe he propoſes to diſſolve it completely in nitric acid. If it contains gold, this remains in the ſtate of powder at the bottom of the ſolution ; if it contains biſmuth, it is precipitated by water, which does not ſeparate the oxide of mercury. Silver is diſcovered by precipitating the ſolution with muriate of ſoda ; the muriate of ſilver and that of mercury are depoſited together, but the latter diſſolves in the water much ſooner than the former, and they are ſeparated by means of this ſimple proceſs. It might be done ſtill better by means of the oxigenated muriatic acid, which would diſſolve the muriate of mercury without affecting the muriate of ſilver. The docimaſtic proceſſes are the ſame for the native amalgams.

33. The red ſulphuret of mercury is more difficult to be treated with the acids, which do not attack it without great difficulty. However it is decompoſed by boiling it ſlightly with eight times its weight of a mixture of three parts of nitric and one of muriatic acid ; the metallic part is diſſolved, and the ſulphur is left in the form of a yellowiſh powder. I propoſe to ſubſtitute the oxigenated muriatic acid inſtead of this mixed acid. Bergman had already propoſed to treat this ſulphuret with muriatic acid and the oxide of mangaueſe;

but as the mixture of the latter renders the ſulphur very difficult to be ſeparated, I prefer the immediate action of the oxigenated muriatic acid. By this means we find that 100 parts of red ſulphuret of mercury contain 0,80 of metal, and 0,20 of ſulphur. The mercury, in this natural combination, is manifeſtly in the ſtate of an oxide, and this compound would better deſerve the name of ſulphurated oxide of mercury than that of ſulphuret of mercury.

34. As to the native muriate and ſulphuret of mercury, Bergman directs us to treat them with the muriatic acid, which ſeizes upon the oxide of mercury combined with a portion of ſulphuric acid, and thus reduces the whole maſs to the ſtate of muriate of mercury: the liquid which floats at the top is ſeparated by means of the muriate of barites, which gives the weight of the ſulphuric acid contained in the native ſalt, by means of the precipitated ſulphate of barites, and conſequently that of the muriate of mercury which was originally mixed with it.

35. To theſe docimaſtic proceſſes I muſt add the methods of aſcertaining the purity of mercury, and thoſe of procuring it in a very pure ſtate. Motives of gain frequently afford an inducement for adulterating this metal, which always bears a more or leſs high price in commerce. The additions of lead and biſmuth, the amalgams of which, though ſolid by themſelves, have the property of aſſuming a con-

ſiderable degree of fluidity when mixed, are the moſt common means of adulterating mercury, which is very little changed thereby with reſpect to its fluidity.

Several authors have aſſerted, that it might contain one fourth part of its weight of this adulteration, without any very ſenſible effect upon its liquidity. Mercury is judged to be impure by the combination of all the criteria indicated by authors; by its varied and tarniſhed colour, the impurities and droſs with which it is covered; by thoſe which it leaves upon white glazed veſſels, over the ſurface of which it is paſſed; by the black colour with which it ſoils the hands, or white ſubſtances upon which it is rubbed; by its not dividing eaſily into round globules, but ſeeming to become flattened and wrinkled, to adhere to the veſſels when it is poured out, to become rough at its edges, to leave a train or tail; by the globules not uniting readily when placed in contact with each other; by the quantity of black and grey powder, and of particles, foreign to its nature, which remain upon the ſkin through which it is paſſed; by the black powder which it affords when agitated with water; by its not evaporating ſpeedily and entirely when expoſed to the action of fire; by its leaving a ſtain upon the bodies in which it has been heated; by its yielding coloured ſolutions in the acids; and laſtly, by the circumſtances, that when a ſmall portion of it is heated in a new iron ſpoon, it depoſits, as it becomes volatilized, a dirty and fixed cruſt, formed by the foreign matters which it contained.

36. I ſhall obſerve upon all theſe criteria and characteriſtics of the impurity of mercury which have juſt been mentioned, that the criterion, which is the moſt certain and moſt to be depended upon of all, is the diſtillation of this metal in a retort of ſtone-ware, and the examination of the reſiduum which it leaves behind: this, however, is only a preparatory means, which puts us in the way of making a more exact analyſis, by ſhowing whether the mercury which we examine, contains any conſiderable quantity of foreign water; for it has been obſerved, that mercury, becoming volatilized, carried with it a portion of the fixed metals which altered its purity. Moreover, in order to aſcertain the purity of mercury with accuracy, there is no better means than to diſſolve it in the cold in an exceſs of nitric acid; the ſolution becomes turbid on the addition of water, if it contain biſmuth, and the weight of this precipitate indicates that of this metal: it is then completely precipitated by the muriatic acid; and if the precipitate be mixed with muriate of mercury and muriate of lead, the firſt being volatile, and the ſecond fixed and fuſible, we heat it in a glaſs retort, and judge, by comparing the proportions of the ſublimate and of the reſiduum obtained, what was the compoſition of the mixture upon

which we operated. I ſhall add, on this occaſion, that ſince large quantities of mercury have become neceſſary in laboratories for experiments upon the gaſes, I have had frequent occaſion to examine this metal, in order not to be deceived in the purchaſe, and that I have never found it to contain more than four or five hundredths of foreign matter; that I am convinced, that the mercury is frequently ſoiled, covered with powder, tarniſhed, imperfectly liquid, and even draws a tail, without its containing on that account any remarkable quantity of inferior metals, and that theſe properties almoſt always depended upon a commencement of oxidation, or even upon the humidity contracted by the mercury.

37. In order to avoid the danger of employing impure mercury for the important purpoſes to which this metal is appropriated, as well in medicine as in natural philoſophy and chemiſtry, and in ſeveral of the arts, it has always been adviſed to extract it for one's own uſe from the ſulphuret of mercury: this is what has been termed *mercury revived* or *reſuſcitated* from cinnabar, an expreſſion which pretty well expreſſes the oxided ſtate of the mercury in its ore. This operation is uſually performed in chemical and pharmaceutical laboratories, by diſtilling, in a retort of iron or ſtone-ware, a mixture of iron and ſulphurated oxide of mercury either native or artificial; for, as we ſhall ſee hereafter, the artificial compound is much

more frequent in commerce: the iron is added in the proportion of one part to two of cinnabar, and well mixed, in the form of fine filings, with this mercurial compound, by exact trituration. The diſtillation is performed with the precautions already mentioned; a piece of linen that forms a tube, is attached to the beak of the retort, and immerſed in the water with which the receiver is half filled. The iron, whoſe attraction for oxigen and for ſulphur is much greater than that of mercury, diſoxidates and de-ſulphurates the metal, which riſes in the form of vapour, and is condenſed in the water; there remains in the retort a ſulphuret of iron, in which this metal is a little oxidated. The mercury obtained in this manner, when dried and paſſed through a ſkin, is very pure and brilliant.

38. It is by proceſſes analogous to that which has juſt been deſcribed, that mercury is extracted in the large way from its ores. That which is liquid and diſſeminated in globules amongſt the ſtones, is eaſily collected by diluting them in water after they have been pounded; the metal is precipitated, and the water, as it runs off, carries with it the earthy particles. It is in this manner that the native and liquid mercury is extracted at Ydria in Friuli. As to cinnabar, or the natural ſulphuret of mercury, it will immediately be apparent that it cannot be roaſted, either in order to diminiſh its coheſion, or to ſeparate the ſulphur, even in part, for the ſulphuret would be

diſſipated by the action of the fire. As nature almoſt always preſents it mixed either with a calcareous or ferruginous ſubſtance, both theſe gangues become a kind of intermediate agents, very fit for decompoſing the ſulphuret, abſorbing its ſulphur, diſoxidating its metal, and conſequently promoting its volatilization by the heat.

39. The proceſſes uſed in the extraction of mercury, though always founded upon diſtillation, vary according to the places in which they are practiſed. Antoine Juſſieu has deſcribed, in the Memoirs of the Academy of Sciences for the year 1719, the operations performed at Almaden in Spain, for the purpoſe of obtaining this metal. He firſt obſerves, that the mines of this country do not emit any exhalation deleterious to vegetables; that the environs and the ſoil above them are very fertile; that the working of them is attended with no danger to the labourers, and that it is only the convicts employed in their interior, who are attacked with dangerous maladies, on account of the mercury volatilized by the fires which they are obliged to keep burning. The ore of Almaden, according to this author, contains iron and a ſmall quantity of carbonate of lime. It is introduced into a kind of reverberatory furnaces, and the fire is kindled in the aſh-hole. This furnace has no aperture except eight holes at its poſterior part; to each of theſe holes a row of aludels of earth is adapted,

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the laſt of which terminates in a ſmall building at a conſiderable diſtance from the furnace. Between the two extremities of this apparatus, the build ingand the furnace, a ſmall platform is conſtructed, forming two inclined planes, which ſupport the aludels; when any ill-luted joining of theſe ſuffers any of the mercury to eſcape, its globules are collected at the meeting of the inclined planes of this platform. The fire applied to the ſulphuret of mercury effects its decompoſition by means of the lime and iron, which abſorb the ſulphur and oxigen. The mercury reduced into the ſtate of vapour, is partly ſtopped, paſſes into the aludels, and runs down in part by the gentle ſlopes which they have into the ſmall building. When the operation is completed, and the whole of the apparatus cooled, all the aludels are carried into the chamber of this building, in order to empty them, and collect the mercury which they contain, in a cavity in the middle of the chamber, towards which, it ſublimes from all ſides. This mercury is afterwards tranſported in ſkins, and in barrels that contain ſeveral quintals, which go by the name of *bouillons* in commerce.

40. In the Memoirs of the ſame Academy for the year 1776, we find a deſcription of the proceſs employed in the Palatinate for the extraction of mercury, by Citizen Sage. They there uſe a gallery charged with forty-eight retorts of caſt iron an inch thick, more than a metre in

length, and containing about twenty-nine Kilogrammes (ſixty pounds) of materials. Theſe retorts are ſteadily fixed upon the furnace which ſupports them. A mixture of three parts of the ore well ſorted and pounded, and one part of ſlaked lime is introduced into them by means of an iron ladle; they are heated with pit-coal, applied at the two extremities of the furnace, the ſides of which are perforated with ſeveral apertures, which eſtabliſh currents of air, and cauſe the coal to burn. The mercury is ſeparated and volatilized by the re-action of the lime upon the ſulphur; it is collected in earthen receivers adapted to the retorts, and filled with water to about a third of their capacity. This operation occupies ten or eleven hours. It is evidently founded upon the ſame principles as the preceding one, and differs from it only in the form of the apparatus.

E. *Oxidability by the Air.*

41. Formerly, mercury was not thought to be capable of burning, and it was conſidered as unalterable. It was by carefully examining this property that modern chemiſtry made its firſt and moſt valuable diſcoveries, and to theſe the pneumatic doctrine owes its riſe. Mercury is not only oxidable like all the metals, but it has alſo two modes of burning, or two ſpecies of combuſtion, like the greater part of metallic ſubſtances: the one is the ſlight and imperfect

combuſtion, which takes place at a low temperature; the other is the complete and ſtrong combuſtion, which is effected only at a very high temperature. The firſt was for a long time conſidered to be merely a diviſion of the mercury; it has been very well deſcribed in this point of view by Boerhaave. Without knowing the cauſe, he converted mercury by it into a black powder, which he termed *Ethiops per ſe*, and of which he knew both its reductibility by heat, and the diminution of its weight during its reduction. The other, which has been conſidered by the alchemiſts as a kind of fixation or precipitation of mercury, takes place only at its temperature of ebullition, and converts it into a red powder, which they termed *mercury precipitated per ſe.* Each of theſe muſt be conſidered in detail.

42. The ſlight oxidation of mercury takes place at a very low temperature, and always when this metal is agitated in contact with the air. Ariſtotle already ſeems to have known it, when he ſays in his fourth book (*meteorolog. comm.* chap. xviii.), that by mixing mercury for a long time with ſaliva, a remedy is formed, which is uſeful in ſome diſeaſes of the ſkin. Whether we rub the mercury with the hand, or frequently agitate it in the air, or, as Boerhaave did, cauſe it to be inceſſantly ſhaken in a bottle attached to the axis of a mill-ſtone, or triturate it with any liquids, provided they be thick, viſcid and eſpecially if ſuſceptible of attract-

ing the oxigen of the atmoſphere; in all theſe caſes, it is converted into black oxide, of an acrid and copperiſh taſte, which is reſtored to the ſtate of liquid mercury by the action of fire, and even of light, which contains about a twenty-ſixth of its weight of oxigen, and which is a real black oxide of this metal. We cannot rub mercury upon a white ſubſtance, or between the fingers, without oxidating a portion of it, and in all the operations, of which Plenck has performed ſuch a variety, wherein the metal is extinguiſhed in liquid viſcous mixtures, or in any ſolids, that is to ſay, in which it loſes its form of globules, and aſſumes that of a black powder, with the aid of motion and diviſion in contact with the air, it is equally oxidated. The ſurface of mercury, when expoſed for a long time to the air, even though it be at reſt, becomes at length covered with a dull-coloured pellicle, which is nothing elſe than this ſpecies of oxide. Bernouilli, has even obſerved that on letting a globule of mercury fall from a height of thirty, and even of fifteen centimetres, upon a very brilliant and pure maſs of this metal, a ſpot was formed at the place upon which it had fallen; and though he has attributed it to the impurites which the globule abſorbed in the air, it is evident that it is entirely owing to the commencement of oxidation which it undergoes. This converſion into black oxide is even produced by agitating mercury in aërated water. The ſame oxidation is likewiſe the cauſe of the black powder which frequently forms at the top of old barometers, which contain a ſmall quantity of air. Laſtly, if we obſerve with attention all the circumſtances in which mercury becomes oxidated, by whatever proceſs it may be, we find that it always paſſes through this ſtate of black oxide, before it arrives at a more complete ſtate of oxidation. In a word, this ſtate of black oxide is conſtantly the firſt term of the oxidation of this metal, and we may equally obſerve, that it returns to it immediately before it aſſumes the metallic form, in all the caſes of diſoxidation, of which I ſhall ſoon have occaſion to ſpeak.

43. The ſtrong or complete oxidation of mercury is an operation which the alchemiſts have long ſince practiſed, as I have already obſerved, and for which they have contrived apparatuſes more or leſs complicated, which at preſent are altogether laid aſide. Boyle, who was ignorant of the theory, though he occupied himſelf ſo much with the effects of the air, contrived for this proceſs a flat bottle, which he cloſed with a long cylindrical ſtopper, perforated with a very ſmall aperture through the middle, and which has been termed *Boyle's hell*, from the notion that the metal was put to a real torture in it. Boerhaave, in his numerous diſtillations of this metal, obſerved that he every time obtained a certain quantity of red powder,

very brilliant, very acrid, and very active, ſo as to produce, according to his expreſſion, a great derangement in the animal economy. He alſo diſcovered that this red powder was reducible into mercury by the action of fire; that the metal, by changing its form in this manner, acquired alſo fixity; but he ſuppoſed the cauſe of this change, which he admitted only in the form, to proceed from the fire, which paſſed through the veſſels. In treating of this ſubject he has contented himſelf with combating the pretenſions of the alchemiſts, and aſſerting that the mercury, in this caſe, was converted neither into gold nor ſilver. The complete oxidation of mercury into the red oxide has long been a very tedious and embarraſſing operation in chemical laboratories; it was formerly neceſſary to employ ſeveral entire months in order to obtain a ſlight portion of this oxide; at preſent we ſucceed much more eaſily by means of a very ſimple apparatus. As the volatility of mercury is the obſtacle to its complete combuſtion, ſince it cannot take place unleſs it be raiſed to a temperature ſufficient to make it boil, chemiſts have contrived to give it a ſufficient contact with the air to enable it to abſorb the oxigen requiſite to its oxidation, without affording it an aperture ſufficiently large to admit of its being diſſipated in the atmoſphere. For this purpoſe we take flat-bottomed matraſſes, into which we introduce of very pure mercury as much as will entirely cover the whole lower ſurface with a ſtratum two or three centimetres in depth. The neck of theſe veſſels is then drawn at the lamp till it is reduced almoſt to a capillary tube, and its extremity is broken in order to open a ſlight communication with the air. The matraſſes are placed in a ſand-bath, in which they are immerſed as far as the place to which the mercury riſes; a ſufficient heat is applied to make the mercury boil gently, and in this ſtate it is conſtantly kept. The metal riſes in vapours, but falls back again, except the ſmall portion which adheres to the ſides of the matraſs. After ſome hours, the ſurface of the mercury aſſumes a manifeſtly black colour, in conſequence of the commencement of oxidation which it undergoes; after it has been continually expoſed to the fire for ſome days, red particles are obſerved on its ſurface, which gradually increaſe in quantity, and at length entirely cover it; the motion of ebullition keeps them ſeparate, and impels them to the ſides, where they accumulate, as they are formed without interruption. When the motion is not too violent, ſeveral particles of red oxide collect and form tranſparent cryſtals of a ruby colour, which appear to be octahedrons, or elongated quadrangular pyramids. Almoſt all the mercury introduced into the matraſs may be converted into red oxide, by containing the operation for ſeveral months in ſucceſſion.

ceſſion. It is procured in ſufficient abundance by placing a great number of theſe ſmall matraſſes in a large ſand-bath; the operation goes on much more rapidly and the cryſtals of the oxide are much more perfectly formed, and more brilliant, if we cauſe pure oxigen gas, extracted from the ſuper-oxigenated muriate of pot-aſh, to paſs into the matraſſes.

44. The red oxide of mercury obtained in this manner contains nearly a tenth part of its weight of oxigen, according to the reſearches of Lavoiſier. It is not only very acrid, purgative, and emetic, as Boerhaave obſerved, but alſo cauſtic and corroſive; it is a medicine ſo violent in its effects, that it ought to be reckoned amongſt the poiſons. If we heat it in open veſſels, it ſublimes into a tranſparent vitriform ſubſtance, of the moſt beautiful ruby-red colour. When it is gently heated, and conſtantly agitated in the air, it becomes brown, and nearly of the colour of tobacco. When ſtrongly heated in cloſe veſſels, in the pneumato-chemical apparatus, it yields pure oxigen gas, and is reduced. It was by this experiment that Dr. Prieſtley, made the celebrated and uſeful diſcovery of this gas, in the year 1774; and it is upon the inveſtigation of this reduction, compared with the inverſe experiment of the decompoſition of the air, its alteration, and its partial abſorption by the metals, which increaſe proportionably in weight, that Lavoiſier has laid the firſt foundations of

the pneumatic doctrine. This is therefore a very intereſting oxide to chemiſts, as it has been the ſource of one of the moſt illuſtrious diſcoveries, and one of the moſt important truths which our age can boaſt. Whenever we carefully obſerve the phenomena of its reduction, performed with caution, we ſee it grow brown in proportion as it gives out its oxigen in the form of gas; and there frequently remain ſome particles of black oxide in the veſſel which has been uſed for this operation: the mere contact of the light of the ſun, continued for a long time, is ſufficient to effect, or at leaſt to commence this reduction; this contact cauſes it to paſs again to the brown, the orange, and the yellow colour.

45. We have a new and ſtrong proof, both of the difference of the two oxides, the black and the red, which are obtained by the immediate combuſtion of the mercury, and of the ſuperior ſtrength of attraction of the firſt portion of this principle over that of the ſecond, in the relinquiſhing of this laſt portion, of that which cauſes the oxide to paſs from the black to the red ſtate; which this oxide, in the laſt-mentioned ſtate, makes to running mercury when triturated together with it. I have found, that by this trituration, the running mercury ſoon loſes its luſtre, its metallic ſtate; its fluidity is extinguiſhed, according to the common expreſſion, and by cauſing the red oxide to paſs

to the brown or blackiſh ſtate, ſhows that it divides with it the portion of oxigen in queſtion. Moreover we ſhall ſee, by ſeveral facts which ſhall be mentioned hereafter, that, in the oxide of this metal, the oxigen poſſeſſes but little ſolidity, having loſt only a ſmall portion of its ſolvent caloric; that it is on this account that its formation is ſo tardy, and that it is ſo readily decompoſed, and ſo eaſily relinquiſhes its oxigen; that it adheres ſo ſlightly to it, that it abandons this principle to a great number of other combuſtible ſubſtances, and ſo eaſily and violently inflames ſeveral of theſe, eſpecially ſome of the metals, as zinc, tin, &c.

F. *Union with Combuſtible Bodies.*

46. Mercury contracts no union with azote, hidrogen and carbon: we know of no azoturet, hidruret, or carburet of mercury; but the two laſt mentioned combuſtible ſubſtances act ſenſibly upon its red oxide. Hidrogen kept long in contact with this oxide in the cold, colours it by degrees, and cauſes it to paſs into the ſtate of black oxide. This experiment ſucceeds much more quickly by heat. If we cauſe hidrogen gas to paſs through a tube containing red oxide of mercury, heated to the firſt point of ignition a detonation takes place; the mercury paſſes into the metallic ſtate, ſome remains of black

oxide are left in the tube, and the water that has been formed is diſengaged. This detonation proves that the oxigen which ſaturates the mercury is not in a very ſolid ſtate, and that it retains a large portion of its original ſolvent caloric, which ſeparates in its union with the hidrogen.

47. Carbon does not reduce the oxide of mercury unleſs by the aid of heat. This operation, which affords carbonic acid gas and running mercury, is one of thoſe which ought to be repeated with the greateſt care in experiments performed for the purpoſes of demonſtration, as it is one of thoſe which prove moſt inconteſtibly, and at the ſame time, the exiſtence of oxigen in the metallic oxides, the proportion and nature of the carbonic acid, and the reſpective quantities of this principle and of carbon, which enter into the compoſition of the gaſeous acid produced. By means of a ſimple calculation, it may be performed in ſo exact a manner, that no carbon ſhall be left behind, and the whole mixture ſhall be converted into pure running mercury and carbonic acid gas.

48. Phoſphorus does not unite with mercury without great difficulty, and only by particular management.

A. Pelletier having expoſed upon a ſand-bath, for a ſpace of nearly three months, a ſmall matraſs half full of water, at the bottom of which he had put equal parts of mercury and phoſphorus, which remained always fuſed by means of the temperature of the bath, and which he agitated from time to time, theſe two ſubſtances formed no union with each other, but remained ſeparate. The lower part of the concrete phoſphorus which reſted upon the mercury, having become brilliant and of a ſilver colour by the adheſion of this metal to its ſurface, announced, however, the exiſtence of an attraction between theſe two bodies, and induced Pelletier to attempt their combination by other proceſſes.

B. Having put equal parts of phoſphorus and mercury into a ſmall retort, he diſtilled till a ſmall quantity of phoſphorus paſſed over, after which, he ſuffered the apparatus to cool. The retort being broken, exhibited the mercury and the phoſphorus ſeparate, and without any combination.

C. Equal parts of phoſphorus and red oxide of mercury, (about eight grammes of each in all theſe experiments) being covered with a ſmall quantity of water in a matraſs, were expoſed to the heat of a ſand-bath, and ſtirred from time to time; the oxide ſoon became blackiſh, and united with the phoſphorus; the water contained phoſphoric acid. Pelletier conſiders the black powder to be mercury in a ſtate of diviſion, and conceives this diviſion to be neceſſary to the phoſphoration: it is very poſſible that this metal might have become phoſphorated in its ſtate of black oxide.

D. The phoſphuret of mercury thus formed, becomes ſoft in boiling water, and aſſumes conſiſtence in the cold: when kept in very hot water, after having been incloſed in chamois leather, and ſlightly preſſed, a ſmall quantity of tranſparent phoſphorus was ſeparated. What remained in the ſkin was ſolid black mercurial phoſphuret, which could be cut with a knife, containing in its interior part uncombined globules of mercury. When heated in a diſtilling apparatus, it is decompoſed, and yields phoſphorus and mercury in a ſeparate ſtate. Expoſed to a dry atmoſphere, it diffuſes white vapours that have a phoſphoric ſmell. There exiſts, therefore, no very intimate union between the mercury and phoſphorus.

49. Mercury unites very readily with ſulphur, both by ſimple trituration in the cold, and by the action of the fire. When we triturate this liquid metal with two parts of ſulphur, we ſoon perceive the murcury to diſappear, become extinguiſhed, aſſume and give to the ſulphur a black colour, on which account this preparation was formerly termed *Ethiops Mineral.*

The mere inſpection of the experiment is ſufficient to ſhow that in this operation the mercury is converted into the ſtate of black oxide, and that the ſame holds good in its combination with ſulphur, as in that with phoſphorus of which I have juſt treated; namely, that it unites with it only in the ſtate of black oxide. When the mercury has entirely loſt its form and metallic luſtre; when it is entirely converted into an uniform and homogeneous black powder, which grows blacker and blacker by the contact of the air, the operation is completed; the black ſulphuret of mercury is prepared. In order to prove that in this trituration ſomething more than a ſimple mixture takes place, that the ſulphur actually combines with and adheres to the mercury, Chemiſts have obſerved, that they cannot be ſeparated except by chemical means, and with the aid of the attraction of ſeveral other bodies. Notwithſtanding this commencement of combination, a ſtrong magnifying glaſs enables us to diſtinguiſh oblong globules of mercury in the black ſulphuret formed in the cold, and by ſimple trituration: it whitens gold when rubbed upon it; it diffuſes a fetid ſmell, and yields a black pellicle when treated with the liquid alkalis; it contains more ſulphur than the following, and the two ſubſtances which compoſe it are leſs adhering, leſs intimately combined with each other.

50. When we throw mercury in a ſtate of very minute diviſion, by preſſing and cauſing it to fall in a ſhower, through chamois leather into an equal quantity of fuſed ſulphur, and agitate the mixture, the black oxidation of the mercury, and its combination with the ſulphur, which aſſumes the ſame colour, take place very ſpeedily. We muſt ſtir the mixture without interruption, remove the mixture from the fire,

when the mercury has almoſt intirely diſappeared, and continue to ſtir it after it has been taken off the fire, till by refrigeration and agitation, the whole is converted into ſmall clots; theſe are pounded in a mortar into a fine powder, which is paſſed through a fine ſieve, and preſerved under the name of *black ſulphuret by fire*, or *Ethiops mineral by fuſion*. All chemiſts agree in aſſerting, that in this ſulphuret, the ſulphur and the mercury are more intimately combined than in that which is made in the cold. Wallerius aſſumed, as its characteriſtics of diſtinction from the former, its not whitening gold, its containing leſs ſulphur, its not preſenting globules of mercury viſible by the magnifying glaſs, but ſhining and radiated particles, like a ſulphureous ore; its not forming pellicles, and its diffuſing a much weaker ſmell when ſubjected to the action of alkaline leys. It is obſerved, moreover, in preparing it, that this combination made by the action of fire, is very ſuſceptible of inflammation; and when this takes place, it is extinguiſhed in order to preſerve its ſtate of black ſulphuret; otherwiſe it would paſs into the violet, and aſſume the character of the red ſulphuret.

51. A black ſulphuret of mercury is alſo formed by triturating the red oxide of mercury for ſome time with ſulphur. We muſt be cautious not to heat this mixture too much when we wiſh to promote it by the action of fire; for it is ſuſceptible of detonation, according to the

periments of Bayen, who has made all the oxides of mercury fulminate, indeed by a ſmall quantity of ſulphur, and by heating them ſtrongly. The ſame combination into black ſulphuret takes place alſo when we agitate mercury in water charged with ſulphurated hidrogen gas, as I have diſcovered in analyzing the water of Montmorency; by treating the red oxide of mercury, or precipitating its acid ſolutions, by the ſame water, or by the alkaline hidro-ſulphurets. It is therefore evident that, whether we take running mercury, or treat the moſt perfect oxides of mercury with ſulphur in a ſtate of diviſion, this metal always paſſes into the ſtate of black oxide, in order to combine with the ſulphur. In the firſt caſe, it abſorbs from the air about a twentieth part of its weight of oxigen, which it requires for its converſion into the ſtate of black oxide; in the ſecond caſe, it loſes, on the contrary, all that it contains of this principle, exceeding one-twentieth part of its weight only, which it requires in order to unite with the ſulphur: hence it is concluded that the *Ethiops mineral* of the ancient chemiſts is really the *ſulphurated black oxide of mercury*.

52. The rapidity with which running mercury becomes oxidated, and abſorbs the twentieth part of its weight of oxigen, at the moment when it is combined with ſulphur, proves that in this combination its attraction for the principle of combuſtion is increaſed; it does

not even remain in this firſt degree of oxidation, when the temperature of the ſulphurated black oxide of mercury is raiſed. When we heat this compound in an open veſſel, the ſulphur which exiſts in it in a ſtate of very minute diviſion, and which is conſequently very much diſpoſed to burn, ſoon inflames and is converted into ſulphureous acid vapour; the mercury at the ſame time experiences a higher degree of oxidation, and after having loſt the greater part of its ſulphur, ſo as to retain, to all appearance, not more than an eighth, or even a tenth of its weight, it paſſes into the ſtate of a powder of a very deep violet colour, when the combuſtion of the more abundant portion of the ſulphur contained in the ſulphurated black oxide of mercury has ceaſed. If in this ſtate of violet powder we heat the compound thus modified, in a matraſs, with a ſtrong fire, it ſublimes into a cake of a deep ſhining red colour, exhibiting cryſtals in the form of needles, which in the ancient nomenclature was termed *artificial* cinnabar, becauſe it very much reſembles the natural cinnabar, and which I term *the red ſulphurated oxide of mercury*. The authors of chemical proceſſes vary amongſt themſelves with reſpect to the mode of preparing this compound. That which ſucceeds the beſt and yields the fineſt product, has been deſcribed by Vogel. Seven parts of mercury, paſſed through leather, are mixed with one part of fuſed ſulphur in an earthen veſſel, and the mixture is well ſtirred till it is completely converted into black ſulphurated oxide. This ſulphuret is put into a phial, or rather a matraſs, which is placed in a crucible containing ſand, and this is gradually heated till the fire acts upon it with ſufficient force, and till the matter is perceived to be ſublimed in the upper part of the glaſs veſſel. It is then removed from the crucible, and after it has been broken, we find a red maſs in the form of needles, the colour of which is the more brilliant and beautiful the ſtronger the operation of the fire has been, and the leſs ſulphur the mercury retains. It is ſuperfluous to rectify this red ſulphurated oxide of mercury, and eſpecially to repeat this tedious, difficult, and expenſive operation, ſix or ſeven times in ſucceſſion, as ſome chemiſts recommend; for when it has been well performed, the product is very beautiful and pure after the firſt.

53. Chemical authors differ greatly in their opinions reſpecting the proportions of the principles of the *artificial cinnabar.* Lemery believed it contained ſulphur in the proportion of one part to two of mercury; Cartheuſer in that of 1 to 7⅔; Mender of 1 to 30; Macquer of 1 to 7 or 8. Hence, ſome chemiſts have imagined that this compound might vary according to the relative quantities of ſulphur and mercury employed in the preparation of the *Ethiops mineral,* with which it is fabricated. What is practiſed in this particular in

the manufactories of Holland, proves that ſulphur exiſts in the proportion of leſs than a tenth in this preparation, when it has the quality, which, on account of its fine colour, is in requeſt in the arts. Tuckert, a Dutch apothecary, has deſcribed in Crell's Journal the proceſs of fabrication employed in a laboratory at Amſterdam, in which a great quantity of it was prepared. This proceſs has been publiſhed in the French Annals of Chemiſtry, Tom. IV. p. 25. The black ſulphurated oxide of mercury is firſt prepared, by mixing 150 parts of ſulphur with 1080 of mercury, expoſing this mixture to a moderate fire, in a flat poliſhed iron pan; it is then beat ſmall and put into ſmall earthen flaſks, intended for pouring the matter, in ſeparate portions, into the apparatus in which the red ſulphurated oxide of mercury is prepared. This apparatus conſiſts of three large earthen jars, previouſly covered on the outſide with dried lute, and placed in furnaces ſo that the flame circulates freely round the jars. In the evening a turf fire is kindled under the veſſels, ſo as to heat their bottoms to redneſs; when they are red, the contents of one flaſk is thrown into the firſt jar, that of the ſecond into the ſecond, that of another into the third, and in this manner they continue ſucceſſively to pour into each of them to the amount of two or three flaſks at a time, according to the violence and rapidity of the inflammation; for the black ſulphurated oxide of mercury at this red heat, kindles inſtantaneouſly, and the flame frequently riſes to the height of one, and even two metres above the jars. When this inflammation has ſubſided a little, each jar is cloſed with a plate of caſt iron, which fits it exactly. The operation of pouring the matter into the jars, occupies thirty-four hours, and each of theſe veſſels contains 410 parts of matter; namely, 360 of mercury and 50 of ſulphur. The heat is kept up under the veſſels till the whole of the matter is ſublimed, which requires the fire to be kept burning for thirty-ſix hours: the fire is moderated according to the height of the flame which appears when the cover is taken off; the operation proceeds as it ought, when this flame, though ſufficiently briſk, does not riſe to more than 9 or 12 centimetres height above the mouth of the jars: during this time, the matter is ſtirred every half hour with an iron rake. When the operation is completed and the jars have cooled, they are removed, together with the circles which ſupport them; they are then broken in pieces, and in each are found 400 parts of red ſulphurated oxide, ten parts being loſt in each jar. The workmen aſſured Mr. Tuckert, that they had never met with any accident in performing this operation, during thirteen years that they had been employed in the eſtabliſhment.

54. The circumſtances of this proceſs ſeem to me to prove alſo that the mercury is oxidated

in the artificial cinnabar; and this opinion is beſides ſupported by ſeveral other facts belonging to the preparation of this compound. Whenever we agitate running mercury in a ſolution of hidrogenated ammoniacal ſulphuret, or of hidro-ſulphuret of ammonia, or precipitate a ſolution of this metal by means of either of theſe compounds, we have at firſt a black ſulphurated oxide of mercury; but by being left to ſtand for ſome hours in the liquid, this ſubſtance ſoon aſſumes a brilliant and magnificient red colour. The ſame phenomenon takes place with the ſulphurets with baſes of fixed alkalis or earth, but leſs ſpeedily than with that which has ammonia for its baſis, and the red colour is never equally beautiful, but it remains of a pale brown, or dull brick colour. It has already been proved, that in theſe operations, the mercury does not paſs from its metallic into the black ſtate, otherwiſe than by a commencement of oxidation. It is evident, that in paſſing from the black to the red, it becomes more oxidated, and that it is the oxigen which imparts to it the red colour by which it is diſtinguiſhed; I have therefore thought I ought to term it the *red ſulphurated oxide of mercury.*

55. The characteriſtic properties of this compound are of themſelves ſufficient to prove the oxidated ſtate of the mercury which it contains. It is unalterable by the air; when heated in a cloſe veſſel, it ſublimes without decompoſition;

tion; when gently and gradually heated in an open veſſel, the ſulphur is volatilized, and the reduced mercury is completely diſſipated; this is what takes place when it is employed in fumigations; it does not colour nor whiten gold; the acids do not attack it, though they have in general the property of diſſolving the ſulphurated metals. If ſome of them diſſolve it in courſe of time, they do it without motion or efferveſcence, as they would diſſolve an oxide of mercury. Lime, the alkaline earths in general, and the alkalis decompoſe it; they abſorb from it the ſulphur, and ſeparate the mercury, which is reduced and volatilized, loſing at the ſame time its oxigen by the heat which is employed for this diſtillation. Cobalt, biſmuth, antimony, tin, iron and copper poſſeſs the property of ſeparating the mercury from it by obſorbing the ſulphur. We find alſo that theſe metals are the ſame as deprive mercury of oxigen, and conſequently reduce its oxide. If even it has been found that ſilver diſengages the mercury from cinnabar, and it has thence been inferred that its attraction for ſulphur is ſuperior to that of mercury; but it was not perceived that this proceeded only from a triple attraction exerted in this operation; namely, that of the caloric for the oxigen and the mercury, and that of the ſilver for the ſulphur, with which it unites in proportion as the diſoxidated mercury abandons it, and is no longer capable of remaining in combination with it.

56. In the preparation of the oxide of mercury by the humid way, which is effected by agitating the running metal, eſpecially in the hidrogenated ſulphuret of ammonia, it is poſſible that a portion of the ſulphurated hidrogen may unite with the oxide of the metal which is formed, and that the cinnabar obtained by this proceſs may differ from that which is prepared in the ordinary way. This ſubject well deſerves a particular inveſtigation. It can not be doubted, alſo, that when, in precipitating a ſolution of mercury in an acid, the oxide returns to the black ſtate, a large portion of the oxigen which it loſes is tranſferred to the ſulphurated hidrogen; and that it is on this account that the water, which holds this ſulphurated hidrogen in ſolution, like the ſulphurets hidrogenated with the liquid alkaline ſulphurets, which afford a like reſult with the mercurial ſalts, loſe their fetid ſmell at the moment when they form black ſulphurated oxide of mercury.

57. Mercury unites with many metallic ſubſtances; it diſſolves them, ſoftens them, and forms with them combinations which are termed amalgams: theſe poſſeſs greater ſolidity, in proportion as the quantity of foreign metals which they contain is greater than that of the mercury. Though the action of fire in general decompoſes them, and ſeparates the mercury

which becomes volatilized, yet this metal is rendered, by this combination, a little more fixed than in its natural ſtate, and it is frequently very difficult to ſeparate from it the laſt portions of the foreign metal. Moſt of theſe amalgams are ſuſceptible of cryſtallization.

58. As we can in this place conſider the union of mercury with thoſe metals only of which we have already treated, we ſhall content ourſelves with deſcribing that which it forms with arſenic, biſmuth and antimony, obſerving at the ſame time that it has not been found practicable hitherto to combine it with cobalt, nickel and manganeſe, and that it has never been attempted to combine it with tungſten, molybdena, chromium, titanium and uranium, which are as yet ſo little known, as we have ſeen in the preceding articles, and for the greater part very difficult to be reduced and obtained in the metallic ſtate, and hitherto ſo ſparingly met with.

59. Wallerius doubted the poſſibility of combining arſenic with mercury in the form of an amalgam; but Bergman, in his diſſertation on arſenic has ſpoken in poſitive terms of this combination, in the year 1777. Mercury, according to him, diſſolves arſenic with the aid of fire and continual agitation applied for ſome hours; and forms with it a grey amalgam. The arſenic may be diſengaged from it by the action of heat, but it carries with it a portion

of the mercury. Lehman aſſerts, that the oxide of arſenic alſo combines with mercury, and that, after it has been diſtilled with this metal, a grey powder compoſed of theſe two metals is left at the bottom of the crucible. He tells us that when theſe two ſublimed ſubſtances are re-diſtilled, a new quantity of this arſenico-mercurial powder is always obtained. Henckel had already aſſerted, in his pyritologia, that mercury might ſerve, like fixed alkali, for purifying arſenic; but it is not eaſy to conceive well what authors mean by this, as it is certain that arſenic combined with oxigen cannot yield any of it to mercury, nor form any union with this metal.

60. Biſmuth is one of the brittle metals which combine moſt eaſily with mercury. Pott ſays, that by triturating pulverized biſmuth with mercury and a ſmall quantity of water, we may form them into amalgam; but it ſucceeds better when we pour upon one part of fuſed biſmuth two parts of heated mercury, and agitate the mixture; by this means we obtain an amalgam of conſiderable ſoftneſs, which becomes hard when it is kept for ſome time. Pott even aſſures us, that mercury and biſmuth ſeparate ſpontaneouſly, and that the latter aſſumes the form of powder. The whole of this fluid amalgam paſſes through leather. Since the time of Pott, it has been found that the amalgam of biſmuth is capable of cryſtallizing into pyramids with four

faces, which ſometimes unite into octahedrons; it is alſo ſometimes in thin lamellæ, without any regular form. The cryſtallization takes place when we ſuffer this amalgam to cool ſlowly, after having fuſed it. When it is heated in a retort, it does not give out the mercury which is combined with it, without much difficulty.

61. Mercury does not unite with antimony in the cold; in heat, and when the antimony is well fuſed, if we mix it with thrice its weight of pretty hot mercury, we obtain, according to Wallerius, a ſoft amalgam, of little durability, which is eaſily decompoſed. The ſame chemiſt has obſerved, that by triturating mercury for a long time with antimony, the latter is ſeparated from the former in the form of powder: it is undoubtedly on account of the difficulty of forming this combination, and alſo of the facility with which it is ſpontaneouſly decompoſed, that moſt chemiſts, ſince Wallerius, aſſert almoſt unanimouſly that antimony does not combine with mercury: the ſame is alſo the caſe with the ſulphuret of antimony.

62. The oxide of mercury is decompoſed by a great number of metals, which have more attraction than it has for oxigen, and which deprive it of this principle. Frequently, even by heating them in filings with the red oxide of mercury, theſe metals inflame in proportion as they take away the oxigen from the mercury, which they are able to contain in a more

ſolid ſtate, and with which they unite more intimately. The ſame are alſo the habitudes of arſenic, biſmuth, and eſpecially antimony. When we heat them ſtrongly, with thrice or four times their weight of red oxide of mercury, we ſoon obſerve a great number of ſparks, and as it were a ſpecies of detonation in the veſſel, which becomes filled with vapours, and covered with a white pulverulent oxide. The metal which burns in this manner is in fact reduced to a white oxide; the arſenic even converted into arſenic acid, by a ſufficient quantity of red oxide of mercury, and the latter is reduced to the metallic ſtate.

G. *Action upon Water and the Oxides.*

63. WATER exerts no action upon mercury in the cold; it only ſerves to divide it by means of agitation; and when we are able by this means to change it into black oxidated powder, its converſion into oxide is owing to the air contained in the water. Some authors have recommended this preparation under the name of *black calcined mercury*: I mention it here only in order to ſhow with what facility mercury abſorbs oxigen, and tends to burn into black oxide whenever it meets with this principle. In proportion as this metal, when agitated with water, takes oxigen from it, the water abſorbs it from the air and ſupplies to the metal; for it is a rule, that water always

charges itſelf equally with air, and places itſelf in the equilibrium of combination, whenever it is in contact with it.

64. Boiling water produces no more alteration in mercury than cold water. Lemery had already proved, at the end of the laſt century, that this metal loſt nothing of its weight by ebullition in this liquid. Boerhaave, who repeated this experiment with indefatigable patience, and boiled a great number of times conſiderable quantities of water upon four grammes of mercury, was likewiſe convinced, that this metal had not loſt any thing. However, good medical obſervers have well aſcertained, that this water, in which a linen bag, filled with mercury has been ſuſpended during its ebullition, has a very decided anthelmintic or vermifuge property, and it is a very common practice to preſcribe this decoction to children, who frequently void worms after having taken it. Some phyſicians aſcribe ſtill much greater powers to water which has been ſeveral times diſtilled upon mercury; pretending that this water is ſenſibly antiſyphilitic. Wallerius, in order to explain its effects, ſuppoſed that the mercury re-acquired in water, with which it became penetrated, a weight of the matter equal to what it loſt by its ebullition, and that it was on this account that its diminution could not be aſcertained. Graſhuys, who, in his letter to Dr. Maty, in 1754, ſpeaks of the anti-venereal virtue communicated to water by

mercury, advances even that this metal, after being employed for this operation, loſes its former efficacy, and poſſeſſes afterwards no longer the property of killing inſects. However, it muſt be admitted, that it would require experiments ſtill more deciſive than thoſe which have hitherto been performed, in order to afford ſatisfactory evidence of the truth of ſuch aſſertions.

65. What has been ſaid in No. 62, concerning the decompoſition of the red oxide of mercury by means of a great number of metals, proves that mercury is one of thoſe which have the leaſt attraction and adheſion to oxigen: there are accordingly but very few, and thoſe only amongſt the leaſt combuſtible, which are to be examined hereafter, from which it is able to take away oxigen. Nevertheleſs, by triturating running mercury with certain metallic oxides that are very much charged with this principle, and in which the laſt portion which is combined with them, has little adheſion in compariſon with the firſt, which they retain with great force, it is found to be quickly extinguiſhed and converted into black oxide. This does not take place except with thoſe among theſe oxides eſpecially, which are too much oxidated to be ſtill ſoluble in the acids, and in fact, we ſhall ſee hereafter, that the ſame metals, on the other hand, precipitate mercury from its acid ſolutions, in the metallic form, and take its place in thoſe ſolutions.

H. *Action upon the Acids.*

66. It was by the combination of mercury with the different acids, that chemiſts diſcovered the moſt ſingular properties, and at the ſame time the moſt important uſes of this metal. There is no acid which does not act either directly or indirectly upon mercury, or which does not combine with its oxide, and form a ſaline compound more or leſs intereſting in its properties. The phenomena exhibited by theſe different compounds, whether during their formation, or after they have been formed, deſerve to be ſtudied with attention, becauſe they conſtitute one of the moſt remarkable branches of chemiſtry. I ſhall, therefore, deſcribe them with all the proper details, becauſe the treatiſes of chemiſtry do not yet contain theſe details, and becauſe the inveſtigations which I made relative to this ſubject, in the year 1791, ſeem to me to be capable of throwing a new light upon its combinations.

67. Previous to the year 1777, chemiſts had determined only in a very inaccurate manner, the nature of the reciprocal action of the ſulphuric acid and mercury. All that they had done till then, could afford only uncertain and vague notions, on account of the ſtate of the ſcience. At this period, Lavoiſier made uſe of that action in order to determine the nature of the ſulphuric acid; he ſhowed that mercury,

aſſiſted by the action of heat, deprived this acid of a portion of its oxigen, diſengaged ſulphureous gas from it, became itſelf oxidated, and combined with the undecompoſed portion of the acid; that by ſtrongly heating the ſulphate of mercury, ſulphureous acid gas and oxigen gas were obtained, and that the greater part of the mercury returned to the metallic ſtate: but as his intention was only to occupy himſelf with the analyſis of the ſulphuric acid, he has not deſcribed all the phenomena of this combination. Thirteen years after him, in 1790 and 1791, I undertook a much more comprehenſive inveſtigation of the ſubject; I examined with great attention all that paſſed in the reaction of the ſulphuric acid and of mercury: amongſt a great number of new facts which this inveſtigation preſented to me, I perceived ſeveral circumſtances, which had been glanced at, or indicated, but not explained, by Kunckel, Rouelle the elder, Monnet, &c. I have been enabled to diſtinguiſh with preciſion ſeveral ſtates of the union of the oxide of mercury with the ſulphuric acid, which had been miſtaken or confounded. I proceed to give the reſult of my inquiries into this ſubject.

68. The principal cauſe of the numerous varieties preſented by the ſolutions of mercury in the ſulphuric acid, depends leſs upon the proportion of the acid and of the metal, than upon the quantity of oxigen which the latter abſorbs from the acid, according to the tem-

perature in which their reciprocal action exerts itſelf. In fact, the proportion of one part of running mercury to a part and a half of concentrated ſulphuric acid, which are generally taken for this operation, and which are known not to act upon each other in the cold, gives riſe to a great variety of compounds, according to the temperature in which they are treated, and the length of time during which heat is applied to them. This mixture heated to ebullition in a glaſs retort, the curved beak of which is plunged under a bell-glaſs filled with mercury, in the hidrargyro-pneumatic apparatus, yields ſulphureous acid gas. In this operation, the attraction of the mercury for the oxigen is increaſed in proportion to the increaſe of temperature; for at the ordinary temperature, it is much weaker than that of this principle for the ſulphureous acid, and not for the ſulphur as Lavoiſier imagined: in fact, it has been ſhown in another place, that the portion of oxigen which adheres to the ſulphureous acid, brought to the ſulphuric ſtate, adheres to it leſs ſtrongly than that which is united with the ſulphur in the ſulphureous acid. Mercury decompoſes the ſulphuric acid, deprives it of oxigen, and cauſes it to paſs into the ſtate of ſulphureous acid. If we ſtop the operation when the mercury is converted into a white maſs, but not dried, and when a portion of liquid ſtill remains upon the ſurface of this maſs, it contains uncombined ſulphuric acid; it is acrid and corroſive; it reddens the blue vegetable colours; it does not become yellow by the contact of the air; neither cold nor hot water convert it into that yellow powder, which formerly was called *Turpeth mineral*, on account of its colour, and of which I ſhall ſpeak hereafter, provided we uſe the precaution of firſt ſeparating the acid by a ſlight lixiviation with cold water; for otherwiſe it would become yellow by the effect of the heat produced in the re-action of the water and the acid. I term this whole maſs, which reſults from the action and the doſes of ſulphuric acid and mercury that have been indicated, the acid ſulphate of mercury. It cannot form turpeth unleſs when it is heated and deſiccated.

69. This acid ſulphate of mercury may contain very various proportions of ſulphuric acid, accordingly as the original proportion has been varied; for it is very evident, that we ſhould obtain a maſs equally acid, by employing more of this ſubſtance than the proportion above indicated, and accordingly as we might have likewiſe diſengaged a greater or leſs quantity by the action of the fire: it is in general the more ſoluble in water the more acid it contains, as has already been obſerved by all the chemiſts who have ſpoken of this combination before me. But a circumſtance which has eſcaped their obſervation, is, that if we lixiviate the acid ſulphate of mercury with much leſs water than would be requiſite in order to diſſolve it

completely, if we employ this water cold, in ſmall divided doſes, till it no longer produces any change upon the moſt alterable blue paper, there remains a white ſalt without acidity, much leſs acrid and leſs corroſive than the whole ſaline maſs was from which it proceeds, which ought to be conſidered as a really neutral metallic ſalt. I term it ſimply *ſulphate of mercury*, in order to diſtinguiſh it from the preceding. The water of the lixiviations performed as I have mentioned, carries away a part of it with the ſulphuric acid. Such are the characteriſtic properties of this ſulphate, which has not been deſcribed before me. The proportions that have been indicated of ſulphuric acid and mercury, treated as I have directed for obtaining this ſalt, afford a quantity of it nearly equal to half of their whole quantity. It is white; it cryſtallizes in laminæ and very fine needle-formed priſms; its taſte is not very acrid; it requires 500 parts of water at 10 degrees for its ſolution; but it does not require much more than half this quantity when it is boiling. In its dry and cryſtalline form, it contains in 100 parts, 75 of mercury, 8 of oxigen, 12 of ſulphuric acid, and 5 of water. Both cold and hot water diſſolve it completely without either altering or decompoſing it: the pure or cauſtic alkalis and lime-water precipitate it of a greyiſh-black colour. When we add ſulphuric acid to it, we bring it to the ſtate of acid ſulphate above deſcribed:

its ſolubility is then increaſed in proportion to the quantity of acid added; a twelfth part of this renders it ſoluble in 157 parts of water at 10 degrees, and in 33 of boiling water.

70. Though the ſulphuric acid adheres with ſome degree of force to the ſulphate of mercury, we may, however, ſeparate it, as has already been mentioned, by lixiviating the maſs with leſs water than would be requiſite, in order to diſſolve the whole of the acid ſulphate: in mentioning this proceſs above I did not dwell upon the manner in which the water acts upon this ſalt with an exceſs of acid, ſo that it is neceſſary I ſhould reſume the ſubject. I obſerved, that one twelfth of acid added to the neutral ſulphate, rendered it ſoluble in 157 parts of cold water, whilſt, previous to this addition, five hundred parts were requiſite for its ſolution: I ought here to add, that this proportion of ſolubility changes, if, inſtead of employing all at once theſe 157 parts of cold water requiſite for the ſolution of the acid ſulphate of mercury, we do not apply at firſt more than a fourth part of the ſolvent. This quantity of water does not take up merely a fourth part of the neutral ſalt, and a fourth part of the acid which it contains in exceſs, as by reaſoning á priori would lead us to expect; but it takes up the whole of the exceſs of acid, which, now forming a liquid of greater denſity than if it were diluted with the 157 parts of water requiſite for its complete ſolution, diſſolves

much more ſulphate of mercury, and raiſes the ſalt to a ſtate of much greater acidity. The portion of this ſalt that remains after this firſt lixiviation, now requires five hundred parts of water for its ſolution, becauſe it has become a real neutral ſalt. Thus the water employed in ſmall quantity takes up the whole exceſs of acid, and ſuch a portion of ſalt, that this contains a higher exceſs of acid than was contained in the whole original maſs.

71. In order to prepare the turpeth mineral, the ſulphuric mercurial maſs that has been treated of in No. 68 was condenſed by a longer continued action of the fire. A larger quantity of ſulphuric acid was decompoſed; the mercury was more oxidated, and hot water having been afterwards poured upon the maſs, it afforded the yellow powder known by the name of *Turpeth*. In this preparation the oxide was obtained in different ſtates, of a great variety of colours, from the pale citron-yellow almoſt to the orange-red, without its being poſſible formerly to account for theſe differences, and conſequently to conduct the operation in ſuch a manner as to obtain this compound always of the ſame colour and the ſame nature. Of the great number of experiments which I have made upon this compound, I ſhall here enumerate ſuch as may throw a light upon its properties and compoſition.

a. If we do not evaporate the mixture of ſulphuric acid and mercury rather briſkly and by means of an elevated ſteady temperature, if there remain any very perceptible exceſs of acid not decompoſed, or not volatilized, the maſs diſſolves in the water intirely, without aſſuming the yellow colour, and we obtain only a very ſmall quantity of turpeth, by boiling the water for a long time with this maſs; whilſt, on the other hand, when the ſulphuric mercurial maſs is heated for a long time, it ſpontaneouſly aſſumes ſomewhat of a yellow tinge, and ſuddenly acquires a beautiful yellow colour by the contact of the water.

b. Cold water poured upon the laſt-mentioned maſs, gives it a beautiful greeniſh-yellow colour. Boiling water gives it a pure yellow colour, without any mixture of green; alcohol alſo renders it yellow, but in a leſs degree than cold water.

c. Several chemiſts have conſidered turpeth mineral as a ſimple yellow oxide of mercury, containing no ſulphuric acid. Rouelle thought that it contained ſulphuric acid; and my experiments confirm this opinion. By treating the beſt lixiviated turpeth with the muriatic acid, the muriate of barites precipitates ſulphate of this baſe from the ſolution. For this reaſon I term the turpeth mineral *ſulphate with exceſs of oxide of mercury*, or *yellow ſulphate of mercury.*

d. In order to aſcertain the nature of the change which takes place in the neutral ſulphate of mercury, whilſt it paſſes, by means of heat, into the ſtate of yellow ſulphate or turpeth,

peth, I ſtrongly heated the former in a retort of porcelain: firſt, water was diſengaged, afterwards ſulphureous acid gas, then oxigen gas, and at the end of the operation, the mercury paſſed into the metallic and liquid form. At the moment when the ſulphuric acid is diſengaged, the ſalt, heated to redneſs, becomes fuſed and aſſumes a brilliant purple colour. By ſtopping the operation before oxigen gas is diſengaged, and after the ſulphureous acid has been diſengaged, the ſalt is converted into yellow ſulphate.

e. The properties which diſtinguiſh this ſalt with exceſs of oxide of mercury from the neutral and from the acid ſulphate, all tend to prove that the mercury is oxidated in it much more abundantly and ſenſibly. In fact, this yellow ſulphate is decompoſed and diſſolved by the nitric acid, which does not act upon the neutral ſulphate of mercury; it is equally diſſolved by hot muriatic acid, which converts it into ſuper-oxigenated muriate of mercury, or *corroſive ſublimate*, whilſt this acid cauſes the neutral ſulphate to paſs into the ſtate of ſimple muriate of mercury, or *calomel.*

f. The ſulphuric mercurial maſs, heated to the degree at which it yields yellow ſulphate, ſcarcely receives the ſlighteſt tinge of yellow from water which has been boiled a long time before its being employed for this purpoſe.

g. This ſulphate is heavier than the white mercurial maſs from which it proceeds, when we add the weight of the turpeth to that of the portion of ſalt diſſolved by the water at the moment of its preparation.

h. The yellow ſulphate, though it has hitherto been conſidered as inſoluble, actually diſſolves in more than two thouſand parts of water at ten degrees, and in ſix thouſand parts of boiling water: the ſolution is white.

i. Triturated with running mercury, it quickly extinguiſhes it, aſſuming at firſt a deep green colour, and ſoon paſſing together with this into the ſtate of black oxide: when it is boiled with water and a ſmall quantity of mercury, the ſame converſion into black oxide takes place, only more ſlowly than by trituration.

k. All theſe facts prove, that the yellow ſulphate differs from the neutral and acid ſulphates of mercury, by its containing more metal, more oxigen, and much leſs acid; and by the circumſtances that in all caſes in which it is formed at the expenſe of the two others, there is always oxigen added to the oxide, and ſulphuric acid taken away from it, whether it be diſengaged or decompoſed.

l. One hundred parts of yellow ſulphate of mercury gave me ten of ſulphuric acid; ſeventy-ſix of mercury, eleven of oxigen, and three of water.

m. With the aid of heat, it is ſoluble in ſulphuric acid a little diluted. Cold water precipitates from this ſaturated ſolution a white, and boiling water, a yellow oxide; when it contains an exceſs of acid, it is not precipitated by water. We may re-diſſolve the white precipitate in the ſulphuric acid, and prevent the ſolution from being precipitated by an exceſs of acid.

72. Thus all the facts that have been announced, relative to the combination of the ſulphuric acid with mercury, enable us to diſtinguiſh three ſulphates of mercury, viz.

a. The neutral ſulphate of mercury, cryſtallizable, ſoluble in five hundred parts of cold water, forming a grey precipitate by the action of the alkalis, not decompoſable by the nitric acid, forming calomel with the muriatic acid.

b. The acid ſulphate of mercury, more ſoluble than the preceding; forming an orange-coloured precipitate by the alkalis; from which the exceſs of acid, and a portion of the ſalt itſelf, is taken up by a fourth part of the quantity of water that would be requiſite for its complete ſolution, leaving neutral ſulphate of mercury after the ſolution, indecompoſable by the nitric acid.

c. The ſulphate of mercury with exceſs of oxide: it is yellow, ſoluble in two hundred parts of water; forms a grey precipitate by the alkalis; it is decompoſable by the nitric acid; it forms ſuper-oxigenated muriate of mercury with the muriatic acid.

73. Among the differences that diſtinguiſh theſe three ſulphates of mercury, that of their precipitation by the alkaline ſubſtances ought

particularly to be attended to. It is not eaſy to determine why the neutral ſulphate, which is white, is precipitated into a deep grey by the fixed alkalis; but it is evident, that if the acid ſulphate is precipitated in the orange colour by the alkalis, this depends upon its ſuddenly abſorbing oxigen from the atmoſphere, by the aid of the heat which is developed in the mixture. As to ammonia, the action of which upon theſe ſalts has engaged my attention the longeſt, I have found that it precipitated the ſulphates of mercury into a grey, more or leſs verging towards the black, and that it conſtantly cauſed their oxides, in whatever ſtate they might be, to approach to the metallic ſtate, by diminiſhing the proportion of oxigen which they contained. I have found, moreover, that this oxide, precipitated from the ſulphates of mercury by ammonia, was leſs abundant than that which was ſeparated by the earths and the fixed alkalis; and this difference of quantity, which evidently exceeded the ſimple diminution that could proceed from their diſ-oxidation, having ſhown me that the ammonia did not ſeparate all the oxide of the ſulphates of mercury, I diſcovered, by reſearches which this fact induced me to make, that a triple ſalt, or an ammoniaco-mercurial ſulphate was formed: the principal properties of which I ſhall here announce, becauſe the ſame formation of triple ammoniaco-metallic ſalts exiſts in many other ſolutions of metals, and muſt, in courſe of time, lead chemiſts to new and ſtill more important diſcoveries.

74. When we pour ammonia into a ſolution of the neutral ſulphate of mercury, a very abundant grey precipitate is formed, which, when expoſed to the ſun, is partly reduced into running mercury and partly remains in the ſtate of grey powder. The latter is ammoniaco-mercurial ſulphate; it is ſoluble in ammonia; it is not depoſited with the firſt precipitate except when we do not employ an exceſs of ammonia in which it can be diſſolved. When we employ a large quantity of the latter, we have only a ſmall portion of an entirely black precipitate, totally reducible into running mercury by the action of the rays of the ſun; in this caſe the liquor holds the triple ſalt or ammoniaco-mercurial ſulphate in ſolution. In this operation, the ammonia decompoſes only a portion of the neutral ſulphate of mercury, the oxide of which it reduces. The ammoniacal ſulphate that is formed, unites with the other undecompoſed portion of the ſulphate of mercury, and forms a triple ſalt of little ſolubility, but which is ſoluble in an exceſs of ammonia. The ſame decompoſition takes place, attended with another phenomenon, upon this ſulphate of mercury in its ſolid ſtate. When we pour ammonia upon this ſalt, a briſk efferveſcence enſues, and a remarkable crackling noiſe is heard; a diſengagement takes place of azotic gas, produced from the decompoſition of the ammonia by the ſeparated part of the

oxide of mercury; this occupies the bottom of the veſſel in the form of a black powder, and the liquid that ſwims at top holds ammoniaco-mercurial ſulphate in ſolution.

75. When the liquor which holds this ſalt in ſolution, after it has been formed by either of the proceſſes that have been indicated, is evaporated, either with the aſſiſtance of heat or by expoſure to the air, it depoſits at the end of ſome hours, brilliant cryſtals, of a polygonal form, and hard, the ſmalleſt of which, collected together, form a white and *chatoyant* pellicle upon the ſurface. This cryſtallization is owing to the evaporation of the ammonia which held the ſalt in ſolution. If, inſtead of waiting for this regular depoſition, we ſuddenly add a large quantity of water to the ſolution, it becomes white and milky; a white powder is precipitated, which is nothing elſe than the ſame ſalt, but without any regular form, becauſe it is ſeparated ſuddenly: this proceeds from the circumſtance, that the water which is added, divides the liquid, renders it lighter, and ſeizes upon the ammonia; there remains in the fluid ſulphate of ammonia, which may be obtained in the form of cryſtals by evaporation. More of the latter is therefore formed than is requiſite to cauſe the ſulphate of mercury to paſs into the ſtate of ammoniaco-mercurial triſule as in fact is proved by the analyſis of this, which contains more oxide of mercury than the metallic ſulphate alone contained.

76. The ammoniaco-mercurial ſulphate has a pungent and auſtere taſte; when expoſed to the action of heat, it decrepitates, and yields ammonia, azotic gas, a little running mercury, and a ſmall quantity of ſulphite of ammonia: there remains in the retort ſome yellow ſulphate of mercury; it has little ſolubility in water; the alkalis and lime precipitate it into a white powder, which is ſtill a triple ſalt with an exceſs of its baſe, or deprived of a large quantity of its acid. This precipitates when expoſed to the ſun, then blackens, and is reduced into running mercury, by the mutual decompoſition of the mercurial oxide and ammonia. This ammoniaco-mercurial ſulphate is ſoluble in ammonia, of which it retains a portion when it cryſtallizes by the evaporation of this volatile alkali. An hundred parts contain eighteen of ſulphuric acid, thirty-three of ammonia, thirty-nine of mercury, and ten of water. This analyſis proves, that this triple ſalt contains a very large proportion of the two baſes compared with that of the ſulphuric acid; and that in this combination, the attractions differ greatly, between the three ſubſtances which form it, from that which ſubſiſts between any two of them in particular.

77. All that we have juſt been conſidering relates to the decompoſition of the neutral ſulphate of mercury by ammonia. Other phenomena take place in the decompoſition of the acid ſulphate and the yellow ſulphate, or the

ſulphate with exceſs of oxide, by the ſame alkali; but theſe differences are eaſy to be determined from what has already been laid down. Ammonia poured into a ſolution of the acid ſulphate of mercury, forms no precipitate in it, becauſe the alkali, uniting with the exceſs of acid, is transferred, in the form of ammoniacal ſulphate, to the ſulphate of mercury with which it combines into a triple ſalt; it then perfectly reſembles that of the liquor which floats above the black precipitate formed by ammonia in the ſolution of the neutral ſulphate of mercury. The action of the ſame alkali upon the yellow ſulphate is altogether the reverſe of that which it exerts upon the acid ſulphate: here the exceſs of oxide cauſes a much greater quantity of black oxide to be formed, inſtead of a triple ſalt, in conſequence of the action of the ammonia upon this oxide; there is very little of the triple ſalt, or ammoniaco-mercurial ſalt formed.

78. In order to confirm all theſe new reſults reſpecting the formation of this triple ſalt, as to its nature, and eſpecially reſpecting the difference of the ſaturation of the ſulphuric acid by theſe two baſes, which are united with it at the ſame time, I made a mixture of concentrated ſolutions of perfectly neutral ſulphate of mercury, and equally neutral ſulphate of ammonia; a white powder was immediately depoſited, which I recogniſed to be a triple combination, and the liquor that ſwam at top contained a ſmall quantity of un-

combined ſulphuric acid. This laſt-mentioned fact has particularly proved, that the oxide of mercury and the ammonia, in their reciprocal and ſimultaneous union with the ſulphuric acid, require leſs of this acid, than the ſum of theſe two baſes would have required ſeparately, in order to be each particularly ſaturated with it. I have alſo confirmed the cauſe of the portion of oxide of mercury precipitated in the black ſtate, and reduced by the action of ammonia, by particularly examining that of this alkali upon the oxide of mercury formed by means of fire. I ſhall ſpeak again of this action, in one of the ſubſequent Numbers.

79. No action takes place between running mercury, and the ſulphureous acid; and this muſt neceſſarily be the caſe, becauſe mercury decompoſes the ſulphuric acid only ſo far as to reduce it to the ſtate of ſulphureous acid; but a very ſtrong action is exerted between the oxide of mercury, and the laſt-mentioned acid. If we place the red oxide of mercury and ſulphureous acid in contact with each other, the oxide imediately becomes as white as milk, caloric is diſengaged, and the odour of the ſulphureous acid is inſtantaneouſly deſtroyed. When we employ only a ſmall quantity of this acid, ſulphite of mercury is formed; but if we employ a large quantity, the oxide of mercury is completely reduced to the metallic ſtate, and ſulphuric acid is found in the liquor. The laſt mentioned phenomenon is much ac-

celerated by the contact of the rays of the ſun. By this means, conſequently, we can never obtain any thing elſe than ſulphate of mercury. From the circumſtances that in this experiment the red oxide of mercury is firſt converted into the white, and afterwards completely reduced by the ſulphureous acid, we muſt not conclude that it contradicts the decompoſition of the ſulphuric acid by mercury; for there is no ſimilarity between theſe two phenomena: the firſt takes place only in the cold, and the ſecond is effected only with the aid of heat. The ſame experiment proves alſo that the white oxide of mercury contains leſs oxigen than the red.

80. The nitric acid is eaſily and rapidly decompoſed by mercury; this action is much ſtronger than that which it exerts upon the ſulphuric acid. It takes place in the cold, and as ſoon as theſe two ſubſtances are placed in contact with each other; it does not commence ſpontaneouſly, if the acid be too much concentrated, or too much diluted with water; it is accompanied with a diſengagement of nitrous gas; it is one of the means of procuring this gas, and it is the experiment with which Lavoiſier commenced his analyſis of the nitric acid. The aqua-fortis of commerce acts upon mercury, without however diffuſing much red vapour. When the operation is performed in a very long conical veſſel, and when the acid covers the mercury to a conſiderable

height, a phenomenon is often obſerved which has impoſed upon chemiſts. At the commencement of the operation, the acid aſſumes a bluiſh-red colour towards the bottom; this coloration is evidently owing to the nitrous oxide which ſeparates itſelf from the inferior portion of the decompoſed acid; and in fact, this oxide is not then diſengaged in the form of gas, and the colour of the ſolution is augmented as long as there are no bubbles that riſe to the ſurface of the liquor. Small bubbles are ſeen to ariſe from above the mercury, and diſappear in the lower part of this liquid; when the more violent action develops more heat, the nitrous gas eſcapes, and the liquid loſes the colour which it had aſſumed. This phenomenon proves that mercury has more attraction for oxigen than the oxide of azote has. In proportion as it burns, the oxidated metal is diſſolved in the portion of acid, that is not decompoſed, for much more acid is generally employed for this ſolution, than is required in order ſimply to oxidate the metal; and we may divide the whole, in idea, into two parts, relatively to the different action which each of them exerts upon the mercury, namely, the oxidating part, and the ſolvent part. The ſolution ceaſes when the proportion of the mercurial oxide, that has been formed, and that of the nitric acid neceſſary for its ſolution are in equilibrio. This acid may thus diſſolve a quantity of mercury equal to its own weight.

81. The nitric ſolution of mercury, made in the cold, is white and colourleſs; it is very ponderous, and ſo extremely cauſtic, that it is uſed in ſurgery, by the improper name of *mercurial water*, for corroding and deſtroying fungous fleſh. It makes brown and almoſt black ſpots upon the ſkin, which do not diſappear till the cuticle ſeparates or peels off. It imparts the ſame colour to all vegetable and animal ſubſtances, and the tinge is indelible. It affords, either ſpontaneouſly or by evaporation, cryſtals of form very much varied according to the ſtate of the liquor, and the circumſtances that accompany the cryſtallization. I have ſeen them in four different forms, by ſpontaneous evaporation. I obtained tranſparent regular cryſtals, with fourteen facets, formed by the union of two tetrahedral pyramids, truncated as it were, very near to their baſes, and with four angles reſulting from the junction of the pyramids. The ſame ſolution, evaporated and afterwards left to cool, depoſits, at the end of twenty-four hours, a kind of acute priſms, ſtriated obliquely acroſs, and formed by the ſucceſſive oppoſition of ſmall lamellæ, lying one upon the other in the manner of tiles. Theſe lamellæ, when examined with care, appear to be the ſame maſſes with fourteen facets as the cryſtals above mentioned, but ſmaller and more regular than

thoſe. A nitric ſolution, effected by the aid of a gentle heat, affords, when it is cooled, very long and ſharp flat needles, ſtriated lengthways; theſe are the cryſtals moſt frequently obtained: they have been deſcribed by moſt of the writers on chemiſtry, eſpecially by Macquer and Rouelle. Finally, there is a fourth form, which is very irregular; namely, that of a white maſs, frequently filled with long, ſilky, flexible, minute needles; but this belongs to another ſolution, or another modification of the nitrate of mercury, the properties of which it is neceſſary that we ſhould conſider.

82. Though ſome chemiſts have indicated the ſtate of this ſecond nitric ſolution before Bergman, it is to him that we are indebted for our firſt accurate knowledge of this remarkable modification of the mercurial nitrate. This illuſtrious chemiſt has obſerved, in his Diſſertation on the Analyſis of waters, that the nitric ſolutions of mercury differ from each other, according to the manner in which they have been prepared. That which is made in the cold, of which I have already treated, and which was not attended with any extrication of red vapours, is not decompoſable by diſtilled water; but if the ſolution has been effected with the aid of heat, if a large quantity of nitrous gas has been diſengaged in the operation, it will be precipitated by water, and it will no longer be capable of being uſed as a ſure re-agent. I ſhall not enter here into a

diſcuſſion of the erroneous theory which Bergman adopted in order to explain this difference; but I ſhall lay down that which I have been led to adopt, by my experiments upon this ſubject. This phenomenon proceeds from the ſame cauſe in the nitric ſolution as in the ſulphuric. This kind of ſolution, with exceſs of mercury, is precipitated by diſtilled water, becauſe this alters the denſity of the liquor, and diminiſhes the adheſion of the oxide of mercury with the nitric acid: accordingly, the precipitate is nitrate, with a great exceſs of mercury, very highly oxidated; and very yellow, if we pour the ſolution into hot water; or white, if we pour it into cold water. We may give the yellow colour of turpeth to the latter by waſhing it in boiling water at the very moment of its precipitation. The ſolution effected in the cold, on the contrary, containing only nitrate without exceſs of mercury, as it is only with the aid of heat that it can charge itſelf with a redundance of oxide, diſtilled water cannot produce any precipitation in it. This propoſition is proved by the circumſtance, that we may render at pleaſure the ſame mercurial ſolution decompoſable or not decompoſable by water, by adding to it either oxide of mercury or acid, and cauſe it to paſs ſeveral times ſucceſſively from one to the other of theſe ſtates. If we add mercury to a nitric ſolution of this metal made in the cold and not precipitable by water, aiding the action by the application of heat, it charges itſelf with freſh oxide, and becomes capable of being precipitated by water. If we heat for ſome time the ſame ſolution of mercury, the nature of which is not changed by the addition of water, it ſoon becomes capable of being changed in this manner, as we have thus diminiſhed the proportion of its acid, and increaſed that of the oxide of mercury, as well as its oxidation, as is proved by the diſengagement of nitrous gas which takes place in this experiment; the oxide, on account of its abundance and its ſurcharge of oxigen, no longer adheres to the acid as it did before, and the water has now the power of ſeparating it, and precipitating it in a white or yellowiſh powder. This kind of ſolution forms with the muriatic acid a ſoluble ſalt, whilſt that of the *neutral nitrate*, or of the acid nitrate of mercury forms an inſoluble ſalt with this acid.

83. The precipitate thus obtained, is not, however, compoſed of all the oxide of mercury combined with the nitric acid: however large a quantity of water we may employ in order to form it, there always exiſts in the liquor, after the ſeparation of its depoſition, a ſmall portion of oxide combined with the remaining acid. I have alſo found that the ſame liquor is capable of yielding cryſtals of nitrate of mercury, and that its habitudes are in many reſpects ſimilar to thoſe of the firſt ſolution which is indecompoſable by water alone. I therefore conclude from all theſe facts, and from all the

facts hitherto known reſpecting the combination of the nitric acid and mercury, that three ſpecies of combination ſubſiſt between this acid and the oxide of this metal, as there are three ſpecies of ſulphates of mercury; and I diſtinguiſh three nitrates according to the ſame principle, and by analogous denominations; viz.

a. The neutral nitrate of mercury: that which is yielded by the ſolution in good condition, or which is not precipitated by water.

b. The acid nitrate of mercury. This is obtained by diſſolving the firſt in water, charged with more or leſs nitric acid, or by adding this acid in any manner to the two other nitrates; it is the moſt frequent product obtained in the greater number of the ſolutions of mercury, made for the purpoſes of pharmacy and of the manufactures.

c. The nitrate with exceſs of oxide of mercury: it exiſts in the ſolution which is precipitated by water, or which was formerly denominated in bad condition, or when we treat the two firſt ſpecies by the action of fire; it frequently paſſes into the ſtate of yellow oxide at the moment of its precipitation, or ſome inſtants after, and becomes what was formerly termed *Nitrous Turpeth.*

84. Though theſe three nitrates reſemble each other in ſeveral of their properties, and in ſome of the phenomena that attend their decompoſition, they, however, preſent ſome differences which it is uſeful to know and appreciate;

ciate; this we may do by examining the characters of the real nitrate of mercury, of that which is neutral, which water does not ſeparate from its ſolution, and which ſo frequently paſſes into the acid ſtate, or the ſtate ſurcharged with oxide, in the different treatments to which it is ſubjected. We ſhall ſoon ſee that the examination of this will naturally conduct us to the knowledge of the two others. The nitrate of mercury, when placed upon a piece of burning charcoal, detonates feebly, though with a ſufficiently bright and briſk flame, if we have taken care to drain it well, or even dried it previouſly between two pieces of paper: when it is moiſt, it fuſes, becomes black, extinguiſhes the portion of lighted charcoal which it occupies, throws out ſmall reddiſh ſparks, with a ſlight decrepitation at its dry ſides. The nitrate with exceſs of acid, boils, becomes liquid very quickly, ſwells conſiderably, exhales a large quantity of red vapour, and detonates only in a very feeble manner. If we heat the neutral nitrate of mercury in a crucible, without the contact of combuſtible matter, it melts, exhales nitrous gas, aſſumes a deep yellow colour, from which it ſoon paſſes to the orange, and from thence to the bright red: in this ſtate it was formerly termed *red precipitate*; in the Methodical Nomenclature it is diſtinguiſhed by the name of *red oxide of mercury by the nitric acid*. It is frequently prepared, in order to ſerve the purpoſe of an eſcharotic in ſurgery, by heating and decompoſing the nitrate in medicinal phials. When this operation is performed ſlowly and cautiouſly, it is obtained in the form of fine brilliant ſcales of the moſt beautiful purple colour, and poſſeſſing a conſiderable degree of acrimony. It does not contain any acid when it is well prepared and homogeneous: it is nothing more than a pure red oxide of mercury, in every reſpect ſimilar to that which is obtained by ſimple oxidation in the air; and thoſe chemiſts who have attributed its cauſticity to the preſence of the nitric acid have been miſtaken. When it ſtill retains any of this acid, it is becauſe it is not true red precipitate, becauſe it has not been ſufficiently heated, and becauſe it ſtill contains ſome portions of yellow nitrate of mercury, which, together with the portion of red oxide that has been formed, conſtitute an orange-coloured powder: accordingly, in order to be well prepared, it is neceſſary that it ſhould be of a beautiful bright purple colour, without mixture of yellow, green, orange, or white. It is very evident that its acrimony depends upon the oxigen and its ſtate of real red oxide. Poſſibly ſome advantage may be gained in ſurgery by not carrying its decompoſition quite ſo far, but by leaving a little nitric acid in it, in order to render it more ſpeedily and powerfully cauſtic: this, however, is not the true red oxide of the chemiſts, who ought to continue the proceſs till it contains no more acid. This experiment proves, that the white oxide of mercury, united in a ſaline form with the nitric acid, at a high temperature, decompoſes this acid, deprives it of its oxigen, reduces it to the ſtate of oxide of azote, paſſes itſelf to the *maximum* of its oxidation, and ſhows that it is a commencement of this action which takes place whenever we heat the ſame ſalt in ſolution, eſpecially when we cauſe it to paſs from the ſtate of neutral nitrate, to that of nitrate with exceſs of oxide, and decompoſable by water.

85. We ſee ſtill better what takes place in this decompoſition of the nitrate of mercury by the fire, if we perform the experiment in a retort; as long as it is fuſed and yellow, it yields acidulous water and nitrous gas. From the moment that it has become red, it yields nothing elſe but oxigen gas, mixed, eſpecially towards the end, with a little azotic gas. In order to obtain this laſt product, a ſtronger fire is requiſite than for the firſt. In proportion as the oxigen gas is diſengaged, the oxide is reduced, and paſſes into the ſtate of running mercury, like the oxide *per ſe*, from which it differs only in the ſmall portion of azotic gas, proceeding from the nitric acid which is found amongſt its aëriform products. It was with this beautiful experiment that Lavoiſier commenced his analyſis of the nitric acid, and it was from this that he gradually aſcended to the general knowledge of the nature of the other acids, and of the theory of acidification.

86. The pure neutral nitrate of mercury, when expoſed to the air in cryſtals, is inceſſantly altered; it gradually abſorbs the atmoſpheric oxigen; it paſſes from the white to the yellow colour; it cannot be preſerved without alteration, except in cloſe veſſels; when it has aſſumed a yellow colour at its ſurface, if we attempt to diſſolve it in water, a powder ſeparates of the ſame colour—pale if the water be cold, and deeper if it be boiling. This was the *nitrous turpeth* of Monnet, and its formation is known from what has been ſaid above. This powder is a yellow oxide, retaining a ſmall quantity of nitric acid; it is a nitrate with exceſs of oxide of mercury, which paſſes more eaſily and ſpeedily into the ſtate of precipitate or red oxide when we heat it, ſince it has already undergone part of its decompoſition as nitrate of mercury. Boiling water renders its colour deeper, not only becauſe it favours its union with the atmoſpheric oxigen, but alſo becauſe it ſeparates from it a portion of white nitrate of mercury which is ſtill mixed with it: it is even remarked that this ſpecies of *nitrous turpeth* is more oxidated than that formed by the ſulphuric acid, as it is much more loaded with oxigen by the firſt than by the ſecond of theſe acids. Accordingly, it paſſes quickly into the ſtate of red oxide by the action of the fire, whilſt that which proceeds from the ſulphuric acid does not undergo this ſpecies of decompoſition but with great difficulty.

87. It muſt eaſily be comprehended, that the nitrate of mercury is not completely ſoluble in water, except when it is very white and very pure: it has been obſerved, that the nitrate with exceſs of acid, is leſs altered in the air, and aſſumes much leſs of a yellow tinge, than the neutral nitrate, and that, in general, at a low temperature, an exceſs of nitric acid oppoſes the oxidation of mercury, and renders the nitrate of this metal more permanent and leſs decompoſable than it is in the pure ſtate. This is a general phenomenon in all the combinations of the metallic oxides with the acids. As theſe cannot diſſolve the oxides, except at a certain term of oxidation, beyond which the latter cannot unite with them, or are ſeparated from them; the acids which are combined with them retain them, and put a period to their oxidability by the air, or at leaſt retard its progreſs by means of the adheſion which they have contracted with them, and this oxidibility reſumes all its force at the moment when the oxides are ſeparated from the acids. The moſt ſtriking example of this effect has been exhibited in the hiſtory of Manganeſe.

88. The nitrate of mercury is decompoſed by all the alkaline ſubſtances with different phenomena, according to its ſtate, and eſpecially according to the degree of the oxidation of the oxide which it contains; for this condition has more influence upon the difference of the precipitates than that of the proportion of nitric acid.

Bergman diſtinguiſhed the two ſolutions of mercury, that which is not precipitated by water, or which is in good condition with reſpect to its uſe as a re-agent, from that which is precipitated by water, and which, in the ſame point of view, is in bad condition, by the diverſity of the precipitates which each of them is ſuſceptible of yielding by means of the alkaline ſubſtances. According to him, the firſt yields, by pot-aſh, an oxide of a white colour, inclining to the yellow; by the carbonate of pot-aſh, a white oxide; by ammonia, an oxide of a greyiſh black; by the ſulphuric acid and the ſulphates, a white granulated powder; by the muriatic acid and the muriates, a precipitate of a thick conſiſtence like curd. The ſecond, more acrid and leſs cryſtallizable, yields yellower or browner precipitates by the fixed alkalis; by ammonia, a white precipitate; by the ſulphuric acid and the ſulphates a yellowiſh precipitate; and by the muriatic acid a more abundant coagulum. The following are the facts which I have obſerved reſpecting the decompoſition of the nitrate of mercury with exceſs of acid by ammonia. This alkali precipitates it in the form of a black powder, in very ſmall quantity, when the alkali is added in great abundance. If we add only a ſmall quantity, the precipitate is of a whitiſh or greyiſh colour; the clear ſolution which ſwims above the precipitate, yields a large quantity of white precipitate when diluted with water; the ſame white depoſition is obtained when we mix nitrate of mercury and nitrite of ammonia; when the liquor that has been rendered turbid by the addition of water is evaporated, it depoſits priſmatic cryſtals with ſix ſides, in proportion as the free ammonia is volatilized. The white precipitate is a neutral ſalt, a kind of very ſoluble ammoniaco-mercurial nitrate, with exceſs of oxide of mercury and of ammonia relatively to the proportion of nitric acid, in which the oxide of mercury appears to be ſaturated with ammonia, and to form a ſort of ammoniacal mercuriate. It is compoſed in fact of 68,20 of oxide of mercury, 16 of ammonia, and 15,80 of nitric acid and water.

89. The combination of the oxide of mercury with the muriatic acid, forms two very important compounds, with which chemiſts have occupied themſelves a great deal during nearly a century paſt, and which have particularly been the ſubject of very fine diſcoveries in the pneumatic doctrine. We might even aſſert, that the numerous facts that had been obſerved and deſcribed relative to the ſalts, previous to the eſtabliſhment of this doctrine, were more fit to obſcure than enlighten the knowledge of their properties. The ſame holds good with the relation of theſe facts to the pneumatic doctrine, as with all thoſe that belong the important hiſtory of mercury: we find in this expoſition, or in the collective view of them, on the one hand, the true foundation of the doctrine of the French chemiſts, and, on the other,

the only happy explanation of their cauſes and effects. This two-fold reaſon exacts that we ſhould inveſtigate with care, and examine in detail, whatever relates to the union of theſe ſubſtances. The Arabs had ſome notions concerning the muriates of mercury, in the tenth and eleventh centuries; the alchemiſts were the firſt who diſcovered and deſcribed them, amongſt the experiments which they made upon the Philoſopher's Stone; the pharmacological chemiſts have particularly occupied themſelves with them. Bergman has inſtituted a long examination of them; but he neither knew their nature, nor ſuſpected their differences, in the year 1769; a period at which, indeed, it was yet impoſſible to comprehend their differences and their compoſition. Citizen Berthollet is the firſt who, after his inquiries reſpecting the oxigenated muriatic acid, has explained the two principal ſtates of muriate of mercury, and has given a clear account of their diſtinctive characters according to his ingenious experiments. Since his diſcoveries, the hiſtory of its important combinations has no longer preſented any obſcurity, but has actually become one of the triumphs of the pneumatic doctrine, as will appear from the expoſition which I purpoſe to give of it.

90. The muriatic acid exerts no action upon mercury, neither in the cold nor with the application of heat. It has however been pretended, that when the acid and the metal are

brought together in the ſtate of vapour, they unite and form a compound ſaline ſublimate. Poulletier-de-la-Salle, the French editor of the Pharmacopœia of London, quotes an experiment, in which he formed corroſive muriate of mercury by this proceſs; but it is evident that only a very ſmall quantity of ſalt can be obtained in this manner, becauſe the mercury, even in the ſtate of vapour, exerting no action either upon water or the muriatic acid, and not being able to take away oxigen from either of theſe ſubſtances, cannot unite with this acid excepting ſo far as it may have been oxidated at firſt by the air of the apparatus; and however large the veſſel may be, it is difficult for the metal to become ſenſibly oxidated by this ſimple proceſs. Accordingly, all the authors who have indicated this proceſs, agree that it furniſhes but very little ſalt, and that it is more curious than uſeful.

91. But though the muriatic acid exerts no action upon mercury, it exerts a very ſtrong one upon the oxides of this metal, as was firſt ſhown by Margraff in 1746. The manner in which theſe oxides are attacked by the muriatic acid, varies according to their ſtate of oxidation and the quantity of oxigen they contain. The black oxide is ſcarcely ſuſceptible of combination with it. The white oxide abſorbs it, and forms with it a black muriate, inſoluble if it be but little oxidated, and a ſoluble muriate when it is more oxidated; for many facts prove that the white

oxide may vary in its oxidation. The yellow oxide, and particularly the red oxide, when brought in contact with the muriatic acid, produce a ſenſible efferveſcence; oxigenated muriatic acid is diſengaged, and the oxide, paſſing to the white colour, unites with the other portion of muriatic acid, ſo as to form a ſoluble muriate. Theſe phenomena prove that the attraction between the oxides of mercury and the muriatic acid is very ſtrong, and already indicate that there may be two kinds of combination between theſe bodies.

92. To this attraction is owing the manner in which this acid acts upon the ſolutions of mercury in the ſulphuric and nitric acids; in general it carries off the oxide of mercury from thoſe acids; but it produces a double effect with theſe two ſalts, according to their ſtate. If we treat the yellow ſulphate of mercury, or the metallic nitrate precipitable by water, as alſo the ſolid yellow nitrate of mercury, with the muriatic acid, we form a ſoluble muriate, which is termed the *corroſive muriate of mercury*, on account of its exceſſive acrimony, and ſometimes *ſuper-oxigenated muriate of mercury*, on account of the ſuper-abundance of oxigen which the ſalt thus prepared contains in its compoſition. If, on the contrary, we treat acid or neutral ſulphate of mercury, or the nitrate of mercury not precipitable by water, with this acid, we obtain in the mixed liquors a heavy, curdled, white, inſoluble, almoſt inſipid

precipitate, which was formerly termed *ſweet mercury*, and which we now diſtinguiſh by the name of muriate of mercury, or mild muriate of mercury. It is to be obſerved, that we obtain the ſame reſults, whether we treat the alkaline muriates, and eſpecially muriate of ſoda, with the ſulphates or nitrates of mercury, with the aid of heat, or mix the ſolutions of theſe different ſalts with each other. The only difference in the products is, that the muriates of mercury are volatilized in the firſt caſe, and precipitated or obtained by evaporation of the liquors in the ſecond; and as theſe ſalts have almoſt always been prepared in chemiſtry in the dry way, the products have been termed the *corroſive* or *mild* ſublimates.

93. When we place running mercury in contact with liquid oxigenated muriatic acid, the metal is quickly oxidated, and converted into a black and grey powder, which diſſolves in this acid when its proportion is ſufficiently large. The ſolution is effected without efferveſcence or motion, for the mercury, in ſeizing upon the oxigen, is not here under the neceſſity of diſengaging that principle from another body which is obliged to eſcape in the form of gas. If the proportion of oxigenated muriatic acid is but ſcanty, it forms a white powder, which is the *mild mercurial muriate*: if we increaſe the proportion of the oxigenated acid, the ſaline powder is re-diſſolved, and the liquor then holds *corroſive mercurial muriate* in ſolution.

It is evident that this proceſs, which is very ſimple and expeditious, is one of the beſt that can be employed for preparing theſe ſalts, though I do not know that it has been practiſed in the manufactories, in which it will ſooner or later be adopted, and in which it will be ſufficient to heat in cloſe veſſels, adapted for ſublimation, a ſort of paſte or mixture made with ſulphate of iron, muriate of ſoda, oxide of mangeneſe, and running mercury; the doſes will be varied, in order to obtain either corroſive muriate, or mild muriate. The theory of theſe operations is very ſimple. The ſulphate of iron, when heated, gives out its ſulphuric acid, which expels the muriatic acid from the marine ſalt; the latter acid being then transferred to the oxide of manganeſe, paſſes into the oxigenated ſtate, ſoon yields its oxigen to the mercury, and unites with its oxide into the ſtate of *mild muriate*, if the muriatic acid be in but ſmall quantity, or into that of *corroſive muriate*, if its quantity be more conſiderable; thus it will be ſufficient to vary the reſpective proportions in order to obtain either the one or the other of theſe products.

94. After what has been ſaid, it is eaſy to conceive that the oxigenated muriatic acid ought to diſſolve all the oxides of mercury much more eaſily than it does the liquid metal; accordingly there is ſcarce one of them with which it does not form almoſt inſtantaneouſly, and at the moment of contact, ſuper-oxigenated

and corroſive muriate. Alſo if we mix this acid with the ſulphates of mercury, in whatever ſtate they may be, it converts them all into corroſive muriate; and if we add it to the nitric ſolutions, it conſtantly re-diſſolves the precipitates which it firſt produces in them, if we apply it in ſufficient quantity; there are even caſes in which it does not produce any ſenſible precipitate in the nitric ſolution of mercury; ſometimes even the ſolution, when it contains a very highly oxidated oxide of mercury, is not rendered turbid by the ordinary muriatic acid, which then forms corroſive muriate of mercury, a proof that the conſiderable proportion of oxigen is the only condition neceſſary to the compoſition of the ſuper-oxigenated muriate of mercury, and that it is indifferent whether this proportion be furniſhed by the acid or by the oxide.

95. There are therefore two very different combinations between the muriatic acid, and the oxide of mercury, which have much analogy with thoſe that have been equally diſtinguiſhed in the hiſtory of the ſulphate and nitrate of the ſame metal, depending, as in theſe, upon the proportion of the oxigen, and which it is eſſentially neceſſary to ſtudy and particularly deſcribe. We ſhall ſoon ſee that there is even a third with exceſs of acid. What has already been ſaid concerning the general nature of theſe muriates, muſt have been ſufficient to prove that they may be prepared in a great

number of different ways. Authors have alſo ſingularly differed from each other with reſpect to the proceſſes proper for forming theſe two ſalts. Wallerius, already in his time, counted ten methods of preparing corroſive ſublimate Bergman, in his diſſertation written in 1769, has deſcribed a great number of them; but there are ſome that are more generally adopted on account of their ſimplicity and ſucceſs. Though I have already indicated a new one which may anſwer the purpoſe of the manufacturers of this ſalt, I ſhall here deſcribe ſome of the methods moſt univerſally employed for preparing the ſuper-oxigenated muriate of mercury, with which I ſhall commence their hiſtory, and I ſhall follow the ſame plan with reſpect to the ſweet muriate of mercury, of which I ſhall ſpeak hereafter.

96. Moſt generally, equal parts of deſiccated nitrate of mercury, decrepitated muriate of ſoda, and ſulphate of iron calcined to whiteneſs are mixed together; this mixture is put into a matraſs, two thirds of which muſt be left empty; and the veſſel is placed in a ſand-bath, which is heated by degrees till the bottom of the matraſs becomes red-hot. After the apparatus has completely cooled, it is broken to pieces, in order to extract the ſuper-oxigenated and corroſive muriate of mercury, which is found ſublimed in the upper part of the matraſs. In this operation, the ſulphuric acid diſengaged from the ſulphate of iron by the

action of the fire decompoſes the muriate of ſoda, whoſe muriatic acid ſeparates the nitric acid from the nitrate of mercury by taking from it a portion of its oxigen; being thus ſurcharged with this principle, it unites with the mercurial oxide, with which it forms the corroſive muriate; nitrous gas is diſengaged; there remains at the bottom of the veſſel a red maſs coloured by the oxide of iron, from which ſulphate of ſoda is extracted by means of water. It is aſſerted, that in the large manufactories in Holland, this product is obtained by expoſing to a violent fire a mixture of equal parts of mercury, muriate of ſoda and ſulphate of iron. In this proceſs, which has been indicated by many authors, it appears that the red oxide of iron, the reſidue of the decompoſition of the ſulphate, yields a ſufficient quantity of oxigen to the muriatic acid to give it the property of transferring itſelf to the mercury, of combining with it, and reducing it to the ſtate of ſuper-oxigenated muriate. It is alſo poſſible to obtain the ſame ſalt, by treating with fire mixtures of ſulphate of iron, muriate of ſoda, and different oxides of mercury obtained by precipitating its ſolutions by an alkali.

97. Boulduc has revived an old proceſs of Kunckel, which alſo ſucceeds very well, and which is more ſimple than the preceding ones: it conſiſts in heating, in a matraſs, a mixture of equal parts of deſiccated acid ſulphate of

mercury, and decrepitated muriate of ſoda. In this caſe, after the ſublimation of the ſuperoxigenated muriate of mercury, pure ſulphate of ſoda remains alone at the bottom of the veſſel. This proceſs is that which of all others affords the pureſt ſuper-oxigenated muriate of mercury; for that from Holland is generally mixed with oxide of iron, or perhaps with muriate of iron, which being decompoſed in every ſublimation to which it is ſubjected, always leaves a ſmall quantity of oxide of this metal at the bottom of the ſubliming veſſels. What has been ſaid concerning the ſulphate of mercury in the preceding numbers, eaſily explains the production of the ſuper-oxigenated muriate of mercury which takes place in the proceſs of Kunckel. The ſtrong oxidation of the mercury ſuffices here in the ſame manner as when the muriatic acid is placed in contact with an oxide of this metal; it is the caſe of the yellow ſulphate which, as has been explained above, conſtantly forms ſuper-oxigenated muriate of mercury with the muriatic acid. Monnet aſſures us, that by treating muriate of ſoda, in a ſubliming veſſel, with the oxide of mercury precipitated from its nitric ſolution by means of fixed alkali, we alſo obtain corroſive ſublimate. This experiment, which appears contradictory to the known attractions, requires to be repeated; no chemiſt, ſince him who propoſed it, has hitherto confirmed its ſucceſs.

98. We may quickly prepare ſuper-oxigenated muriate of mercury, by pouring oxigenated muriatic acid into a nitric ſolution of this metal, and evaporating the liquor when it contains the former acid in ſuper-abundance; the acid of the nitre diſengages itſelf in vapour; a part of the oxigenated muriatic acid is volatilized; and the liquid, after ſufficient evaporation, and having been ſuffered to cool, depoſits regular and pure cryſtals of corroſive mercurial muriate. This proceſs, which is equally compendious, and free from danger of vapours, is particularly well adapted for being uſed in pharmaceutical laboratories; and its product, being very pure, may be eſpecially devoted to medicinal purpoſes: it is not neceſſary to ſublime the ſalt obtained in this manner.

99. The oxigenated or ſuper-oxigenated muriate of mercury. If we place a particle of it upon the tongue, it leaves for a long time a very ſtrong and diſagreeable ſenſation of metallic ſtypticity in the month. This impreſſion, propagated to the fauces and larynx produces a ſpaſmodic conſtriction of thoſe parts, attended with a ſtrangulating ſenſation, which laſts ſeveral hours, and is extremely painful to nervous perſons. Its action upon the ſtomach and inteſtines is ſtill much more violent; if it remains for ſome moments applied to their coats, it corrodes them, penetrates through, or inflames them, and renders them ſphacelous; the parts which it has touched falling off in gan-

grenous ſloughs. Before this terrible effect ſupervenes, it produces rending pains, nauſea, vomiting, convulſions, proſtration of ſtrength, and all the formidable ſymptoms that prognoſticate the ſpeedy death which it occaſions; it is one of theſe ſubſtances which, after having violently excited the vital action, ſubſequently weakens and ſtops them with the greater energy, and by its chemical and deleterious action cauſes the parts which it touches to paſs rapidly into mortification. The deſtructive effects of a powerful cauſtic are eaſily diſtinguiſhable in the traces which it leaves behind after its action. The ancient chemiſts, attributed theſe effects to the preſence of the acid. Nothing however can be more erroneous than this opinion, and at preſent every thing proves that this action is owing to the ſtate of the oxidation of the mercury. From theſe facts we may judge how dangerous it is to preſcribe the ſuper-oxigenated muriate in the ſolid form, as is nevertheleſs ſo inconſiderately done by ignorant perſons.

100. The form of the ſuper-oxigenated muriate of mercury is extremely various. By ſublimation it affords a great number of needles or very fine priſms, lying cloſe againſt each other, which appear to be tetrahedral and compreſſed. Authors have compared them to the beards of feathers and to ſword-blades. When cryſtallized by means of water, it is either in cubes, or in oblique paralellopipedons, or in very ſmall

priſms. Sometimes it affords quadrangular priſms, with ſides alternately narrow and broad, terminated by cuneiform ſummits, and preſenting two inclined planes. It is ſaid to have been alſo obtained in very regular hexahedral priſms. In general it preſents ſharp points at its extremities; and chemiſts have made an improper application of this form, in order to compare it with ſword or dagger-points, imagining thereby to explain its effects upon the animal economy, which is very far from being the product of any mechanical action. Philoſophers have no leſs varied from each other in appreciating its ſpecific gravity. In the *Phyſique* of Coſte, we find it eſtimated at 6,325, whilſt Muſchenbroeck makes it amount to 8,000.

101. This ſalt poſſeſſes a conſiderable degree of volatility, on which account it has received the name of *corroſive ſublimate*. It is eaſily reduced to the ſtate of vapour in the air, and this vapour is extremely dangerous when received into the lungs. It is not decompoſable by the action of caloric, nor does it yield oxigen gas, though ſome modern authors have aſſerted that it does. Were this the caſe, it would become mild muriate of mercury, whereas, it is well known, that it does not undergo this change by the action of fire. It is unalterable by the air, in which, however, it loſes ſomething of its tranſparence, and becomes white, opaque, and pulverulent at its ſurface. It is ſoluble in about 20 parts of cold water; hot water diſ-

ſolves a little more of it; however, it cryſtallizes very little by refrigeration, and regular cryſtals are obtained only by ſlow evaporation. The ſulphuric acid renders it much more ſoluble, but it precipitates it by refrigeration, in an unaltered ſtate, which accords with the decompoſition of the ſulphate of mercury by the muriatic acid and the muriates. The muriatic acid produces the ſame effect upon the ſuper-oxigenated muriate of mercury, and adheres to it ſenſibly, producing a variation in its cryſtallizability; for it is afterwards obtained in no other form than that of ſmall needles, or elſe it can no longer be made to cryſtallize: the nitric acid, in diſſolving it, extricates vapours of oxigenated muriatic acid, according to Bergman, who, however, aſſures us, that it may afterwards be obtained in the cryſtalline form, without having loſt either weight or its other properties.

102. All the earthy and alkaline ſubſtances poſſeſs the power of decompoſing the ſuper-oxigenated muriate of mercury, and precipitating its ſolution. Bergman obſerves, that the fixed alkalis generally produce a red precipitate from it, but that this precipitate varies according to the proportion of the acid, which he believes to be variable, and that it approaches to white when the quantity of the acid is very abundant. It is to be obſerved, on this head, that well neutralized ſuper-oxigenated muriate of mercury, poſſeſſing the property of

turning the ſyrup of violets green, of a regular cryſtalline form, is a metallic ſalt, *ſui generis*, which does not vary in the proportion of its principles; that it was an old error, which had prevailed for a long time, to ſuppoſe a very abundant proportion of acid to be contained in it; for it cannot contain an exceſs of acid, unleſs when it is ill-prepared: the fixed alkalis always precipitate from its pure and neutral ſolution an oxide, which at firſt is of an orange-yellow, and afterwards aſſumes a brick-red colour, in proportion as it abſorbs the atmoſpheric air, as is proved by the identity of the colour which commences at the ſuperior part of the liquor. The alkaline carbonates produce in it a precipitate of a fainter tinge, of a ſimple yellow colour, which does not grow deeper like the former, becauſe the carbonic acid prevents the abſorption of oxigen. The ſolution of the ſuper-oxigenated muriate of mercury is a good re-agent for diſcovering the preſence of an alkali in a liquid, for it is ſenſibly precipitated in a red or yellow ſtate by the ſmalleſt poſſible quantity of this baſe.

103. A mixture of about 300 parts of lime-water, and one part of ſuper-oxigenated muriate of mercury, is prepared for pharmaceutical purpoſes, and termed, on account of its acrimony, *phagadenic water*: as ſoon as the mixture is made, a yellow precipitate is produced, which ſoon paſſes to a brown colour, and is nothing but a mercurial oxide,

capable of acting as a gentle eſcharotic, however ſmall its quantity, and however abundantly diluted with water it may be. It is employed for ſurgical uſes, and the mixture is always agitated whenever it is to be applied.

104. It has long been known, that ammonia, or volatile alkali, precipitates the ſolution of ſuper-oxigenated muriate of mercury in the white ſtate, but the nature of this precipitate was not known. The following experiments conducted me to the knowledge of it. One hundred parts of corroſive muriate of mercury, mixed with ammonia in exceſs, yielded me 86 parts of this white precipitate in a pretty dry ſtate; but ſoda gave me only 75 parts of brick-coloured oxide. The white precipitate has at firſt merely an earthy taſte, which, after ſome moments becomes metallic and diſagreeable; water does not appear to diſſolve it. Diſtilled in a retort, it yields ammonia in the form of gas and of a liquid with azote gas, and 0,86 of mild muriate of mercury. The ſulphuric acid formed with this ſubſtance corroſive muriate and ammoniaco-mercurial ſulphate. The nitric acid converted this precipitate into corroſive muriate and ammoniaco-mercurial nitrate; the muriatic acid diſſolved it entirely, and formed a ſoluble mercurio-ammoniacal muriate, the true *Sal Alembrothi* of the ancient chemiſts, of which I ſhall ſpeak hereafter. An accurate analyſis proved to me that this precipitate contained 0,81 of oxide of mercury, 0,16

of muriatic acid, and 0,03 of ammonia; there remained in the ſupernatant liquor the pure muriate of ammonia. The great difference between the precipitation of the ſuper-oxigenated muriate of mercury, and that of the ſulphate and nitrate of the ſame metal, conſiſts in the circumſtance that there is no oxide of mercury reduced, and that the whole of the precipitate conſtitutes a triple inſoluble ſalt. This ſhows that the ammonia, without decompoſing the ſuper-oxigenated muriate of mercury, and without ſeparating oxide from it, forms a triple ſalt in which this oxide, more abundant than in the corroſive ſublimate, is ſaturated by the ammonia, which it at the ſame time ſaturates after the manner of an acid.

105. All the precipitations of the ſuper-oxigenated muriate of mercury by the alkaline ſubſtances, conduct us to the knowledge of the proportions of the principles of this ſalt, and yet they have not hitherto been accurately determined. According to Tachenius, the mercury is to the acid as 3½ to 1. Lemery gives this proportion : : 5½ : 1. Bergman, who ſeems to come neareſt to the truth, ſays, in his Humid Docimaſia, that 100 parts of ſuper-oxigenated muriate of mercury contain 24,5 of muriatic acid, and 75,5 of mercury; but there is an error in this eſtimate; for if this ſalt contains 0,75 of running mercury, as Bergman announces, it is evident that we muſt ſub-

tract from the 24,5 of acid the proportion of oxigen, which cannot be computed at leſs than between 9 and 12 to the 75,5 of metal: 100 parts of the ſuper-oxigenated muriate of mercury, muſt therefore contain at the higheſt computation 15,5 of muriatic acid, or at the loweſt 12,5. It muſt be left to ſubſequent experiments to determine in how far this eſtimate is deficient, which as yet can be only an approximation to the truth.

106. The ſuper-oxigenated muriate of mercury is decompoſed by water charged with ſulphurated hidrogen gas, as alſo by the hidrogenated ſulphurets and the alkaline hidroſulphurets. Theſe combuſtible mixtures all yield alike a precipitate of black ſulphurated oxide of mercury, which paſſes more or leſs ſpeedily into the red colour, and the fetid ſmell of the hidrogenated ſulphurets is deſtroyed. By means of this proceſs we alſo form a black or red ſulphurated oxide in the humid way. Phoſphorus, which eaſily decompoſes the nitrate of mercury when it is kept for ſome time immerſed in its ſolution, does not ſo eaſily effect the decompoſition of the ſuper-oxigenated muriate of mercury, becauſe its particles poſſeſs a ſtronger adheſion than thoſe of the nitrate. The phoſphorated hidrogen gas precipitates it in a black powder. Carbon exerts no action upon this ſalt, neither in the cold nor in heat.

107. Amongſt the ſalts which have hitherto been examined, the ammoniacal muriate is the

only

only one with whoſe effects upon the ſuper-oxigenated muriate of mercury, we are well acquainted. This combination has long ſince been diſcovered and examined by the alchemiſts, who termed it *Sal Alembroth*, or *Sal Sapientiæ*, as they placed great reliance upon its properties for the attainment of their grand object, and whatever flattered them, in this reſpect, with the chimerical hope of ſucceſs, was decorated in their language as well as in their notions with a pompous title. This is perhaps the firſt triple ſalt that was diſcovered and known. The muriate of ammonia renders the ſuper-oxigenated muriate of mercury much more ſoluble than it naturally is; for one part of the firſt, diſſolved in three of water, renders almoſt five of the ſecond ſoluble in the ſame fluid, though theſe five parts of the latter would require nearly 100 parts of water for their ſolution, if alone. In this experiment, heat is produced on account of the denſity which the liquid aſſumes, and this afterwards becomes ſolid on cooling: there is, therefore, reaſon to believe, that its liquid ſtate depends upon the elevation of temperature which accompanies its ſolution. The ammoniaco-mercurial muriate is equally formed, or rather it is not decompoſed by ſublimation, and the two combined ſalts of which it is compoſed, preſerve their mutual adheſion and combination in the volatilization to which they are ſubjected. When we treat this triple ſalt, formed with equal parts of the two ſalts, with an alkaline carbonate, we obtain the firſt triple ſalt in a white precipitate, formed in other proportions, which has been deſcribed above in the hiſtory of the precipitation of the ſuper-oxigenated muriate of mercury by ammonia. In pharmacy, the ſalt obtained by this laſt mentioned proceſs is termed *white precipitate of mercury,* though this name is alſo given to the ſweet muriate of mercury formed by pouring the muriatic acid into a ſolution of nitrate of mercury; this laſt precipitate is alſo termed *coſmetic mercury,* or *milk of mercury.* In order to diſtinguiſh this ſpecies of white precipitate or triple muriate of mercury and ammonia, from that which is ſoluble, and which was formerly termed *Sal Alembroth,* I deſignate the latter by the name of *ſoluble ammoniaco-mercurial muriate,* and the former by that of *inſoluble mercurio-ammoniacal muriate.*

108. The ſuper-oxigenated muriate of mercury is decompoſable in heat by many metallic ſubſtances, which have more attraction for oxigen than mercury has. Theſe decompoſitions yield, ſome of them mercury reduced into the liquid form, others, metallic muriates, ſometimes ſuper-oxigenated, which are all more or leſs volatile, concreting in the cold, fuſible in a gentle heat, decompoſable by water: they were formerly termed metallic butters; they are more or leſs uſeful in the arts or in pharmacy. It is alſo remarked, that theſe decompoſitions of the ſuper-oxigenated muriate of mercury are

effected by the ſulphurets or the ſulphurated oxides of the ſame metals, and inſtead of having then running mercury, we obtain red ſulphurated oxide of mercury. It is further to be obſerved, that the oxides of theſe metals alone do not in general decompoſe the ſuper-oxigenated muriate of mercury; for this decompoſition being effected only by the attraction of theſe metals for the oxigen which they take away from the mercury, they can no longer produce this effect when they are ſaturated with it. Thus the oxide of arſenic, and thoſe of biſmuth and antimony, do not by themſelves decompoſe the ſuper-oxigenated muriate of mercury, though their metals decompoſe it; but theſe oxides, when combined with ſulphur, decompoſe it, becauſe the oxide of mercury is attracted by the ſulphur; whilſt the muriatic acid on its part attracts each of theſe oxides, which it converts into volatile muriates.

109. This general theory of the action of the metals, and of the metallic ſulphurets upon the ſuper-oxigenated muriate of mercury, is eaſily applicable to each of the particular decompoſitions that are effected upon this ſalt by theſe bodies.

a. When we diſtil, by a gentle heat, two parts of ſuper-oxigenated muriate of mercury with one part of metallic arſenic, previouſly pulverized, and well mixed in a glaſs mortar, there paſſes into the receiver a ſubſtance of the conſiſtence of oil and tranſparent, part of which fixes itſelf into a ſpecies of jelly, which has been termed *corroſive oil*, or *butter of arſenic*, this is the ſublimed muriate of arſenic; the running mercury paſſes over afterwards. The arſenical muriate is decompoſed by water, which precipitates arſenious acid from it. This acrid and cauſtic ſalt ſpeedily deſtroys the organs of animals.

b. Equal parts of ſulphurated oxide of arſenic and ſuper-oxigenated muriate of mercury, yield by diſtillation muriate of arſenic, and red ſulphurated oxide of mercury, which was formerly termed *cinnabar of arſenic.*

c. Two parts of corroſive muriate of mercury, and one part of biſmuth, diſtilled together, produce a thick liquid, partly congealed into the conſiſtence of a very fuſible fat, precipitable by water, diſtinguiſhed by the name of *butter of biſmuth*, and which is the ſublimed muriate of biſmuth. The mercury remains combined with a portion of the biſmuth in a cryſtallized amalgama, or is partly volatilized. Poli, who had deſcribed this experiment in the year 1713, in the Memoirs of the Academy, aſſerts that when this *butter* of biſmuth is repeatedly diſtilled, there remains in the retort a ſhining powder, of the colour of mother of pearl, unctuous, ſoft to the touch, and of ſo beautiful an appearance, that he has propoſed it to be uſed by painters.

d. When one part of pulverized antimony is triturated with two parts of ſuper-oxigenated muriate of mercury, heat is excited which indicates a very violent action between the two ſubſtances, and proceeds merely from the fixation of the oxigen of the mercury in the antimony. This mixture, diſtilled in a glaſs retort, with a gentle heat, yields a thick liquid, of a greaſy appearance, and ſlightly fuming, which fixes itſelf in the receiver, and in the neck of the retort, to the beak of which it hangs like a ſtalactite, in a greyiſh white maſs, frequently in a cryſtalline form, and radiated at its ſurface. This product weighs more than the antimony by one fourth: it was formerly termed *butter of antimony;* we now call it *ſublimed muriate of antimony.* When this ſalt has paſſed over, and the operation is ſtopped, the reſidue is then a ſort of amalgam of antimony; a portion of the latter metal floats at the top in the form of a grey powder. By continuing the application of the heat, and changing the receiver, after having obtained the muriate of antimony, we obtain running mercury. If this operation be performed with the ſulphuret of antimony, there ſublimes after the antimoniated muriate, and by the application of a ſtrong heat, a violet-coloured ſulphurated oxide of mercury, which does not contain a ſufficiency of oxigen to exhibit the bright red colour, and which was formerly termed ſublimed cinnabar of antimony. This proceſs does not ſucceed unleſs with a pora porcelain retort, and a great degree of heat. The ſublimed muriate of antimony, prepared by either of theſe proceſſes, cryſtallizes, by ſlow refrigeration, into very thick paralellopipedons. It is a violent cauſtic, which corrodes and burns the organs of animals, and is employed externally with great ſucceſs, for deſtroying different kinds of virus introduced into the ſkin, and eſpecially the hidrophobic virus introduced by the bite of a rabid animal. The ſublimed muriate of antimony becomes coloured by expoſure to the light and air; it melts and runs like fat in a gentle heat; it attracts the humidity of the atmoſphere, and is reſolved into a thick oleaginous fluid; it is decompoſed and precipitated by water which ſeparates from it a very white oxide of antimony, which formerly was known by the very improper name of *mercury of life*, and that of *powder of algaroth*, after Algarothi an Italian phyſician, who firſt recommended and employed it as an emetic and purgative remedy. The water, after having precipitated it, retains a portion, diſſolved in the muriatic acid which it takes up. The nitric acid diſſolves the ſublimed muriate of antimony, with heat, efferveſcence and extrication of nitrous gas; it forms a nitro-muriate of antimony at firſt in a red liquid, which ſoon depoſits a white powder or magma, when this ſolution is evaporated to dryneſs, and afterwards its weight of nitric acid added, and again evaporated. When this operation has been thrice repeated, and the reſidue laſtly heated in a crucible, which is kept ignited for the ſpace of half an hour, we obtain an oxide white at the top, and of a light roſe colour at the bottom, which was formerly termed *bezoar mineral*, and is analogous to the oxide formed by nitre. We have ſeen that antimony, diſſolved immediately in the muriatic acid, may afford, by ſublimation, the ſame product, which is ſtill better obtained by means of the oxigenated muriatic acid; but it has always been prepared by the decompoſition of the ſuper-oxigenated muriate of mercury.

110. One of the moſt ſingular properties which the ſuper-oxigenated muriate of mercury has preſented to chemiſts, with reſpect to the action which the metals exerciſe upon it, is its union with running mercury, with which it forms the combination known by the name of *ſweet mercury*, or *mild ſublimate* of mercury. The preparation of this kind of ſalt was conſidered as an important ſecret at the beginning of the 17th century. Crollius made a great boaſt of keeping this ſecret concealed. In 1608, Beguin deſcribed it with great accuracy, in his *Tyrocinium Chemicum*, by the name of *draco mitigatus*, on account of the mildneſs which was by that means communicated to the corroſive ſublimate. It became much more gene-

rally known under the name of the *Panchymagogue of Quercetan*, or of *Ducheſne*. Neuman was the firſt who gave it the appellation of *Mercurius dulcis*. It has been known at different periods under the denominations of *Sweet ſublimate*, *Aquila mitigata*, *aquila alba*, *manna metallorum*, *panacea*, *calomelas*, according to the different methods of preparing it. Citizen Baumé, Bergman, and Scheele, are the authors who have treated the beſt concerning this ſalt. The pneumatic doctrine has given an accurate idea of its nature, by defining it as a ſimple muriate of mercury, and thus oppoſing it to the former, denominated the ſuper-oxigenated muriate of mercury.

111. When we triturate this laſt ſalt with running mercury, we ſoon perceive that this metal quickly diſappears, that it is extinguiſhed in the ſalt, and that it aſſumes a blackiſh grey colour. This operation was formerly performed in a mortar of glaſs, mercury being added till it ceaſed to be extinguiſhed; and it was remarked, that in this manner it abſorbed it to the amount of three fourths of its weight. The mixture was then put into retorts, matraſſes, or ſimple phials, two thirds of which were left empty; theſe were placed in a ſand-bath, and ſtrongly heated, till the whole maſs was ſublimed: the veſſels being then ſuffered perfectly to cool, the acrid powder of corroſive ſublimate which was firſt ſublimed, and a blackiſh powder which ſoiled the colour of the product, were ſeparated.

Some authors directed the ſublimation to be performed three ſucceſſive times; and it was after theſe three ſublimations that it was termed *aquila alba.* Others directed it to be triturated again with a freſh quantity of mercury after each ſublimation. Six of theſe ſucceſſive operations formed the *calomel* or *calomelas*; an abſurd denomination, as has been juſtly remarked by Bergman, who ſays, that it has, however, been adopted in Sweden for the ſweet mercury after its firſt ſublimation. According to Malouin, one Labrune carried theſe faſtidious operations ſtill farther; and it was by a ſeries of nine ſucceſſive ſublimations that he directed the mercurial panacea to be prepared.

112. This proceſs is ſo tedious, and attended with ſo many inconveniences, eſpecially the danger of the acrid duſt which riſes during the trituration, notwithſtanding the precaution uſed by the workmen of tying a napkin round their faces, that chemiſts have uſed their utmoſt endeavours to improve and correct it. Citizen Baumé has recommended to pour a ſmall quantity of water upon the ſubſtances that are triturated, to uſe a mortar of porphyry, and to waſh the ſublimed product once in hot-water, in order to diſſolve the portion of ſuper-oxigenated or corroſive muriate which is contained in it. Others have propoſed to employ the grey oxide precipitated from the nitrate of mercury by ammonia, inſtead of mercury, in order to diminiſh

the duration and difficulties of the extinction. Citizen Bailleau has directed us to form a paſte with the ſuper-oxigenated muriate and water, and to triturate it with running mercury, which is extinguiſhed in it very eaſily, and in the ſpace of half an hour, without throwing up the corroſive duſt, afterwards to digeſt the ſubſtance with a gentle heat, which whitens it and promotes the combination, and laſtly, to ſublime the mixture once: this, according to him, is ſufficient for obtaining the product in a very pure ſtate.

113. The theory of this operation is extremely plain and ſimple. The ſuper-oxigenated muriate of mercury very eaſily yields a portion of its oxigen to the mercury: hence the quick extinction of this metal, and the grey colour which the mixture aſſumes, as is the caſe when mercury is triturated with its red oxide: the action between the two bodies ceaſes after the extinction, which is limited in its duration as well as in its proportions; for as ſoon as the diſtribution of the oxigen between the oxide of the corroſive muriate of mercury and the $\frac{3}{4}$ of its weight of mercury has been completed, a permanent equilibrium it eſtabliſhed. The mixture has already loſt its acrimony and ſolubility; but there is not yet any very intimate combination between the two portions of oxide and that of the acid; the heat completes the reciprocal union, which is perfect after one ſublimation; all the ſublimations which are performed after this, and ſtill more ſo the new tri-

turations with mercury, are uſeleſs: and the waſhing with hot water is perfectly ſufficient to carry away the ſmall proportion of corroſive muriate that may ſtill remain in it; the addition of a ſmall quantity of muriate of ammonia to this lixivium, ſtill more certainly inſures the ſeparation of the corroſive ſalt, by the tendency which it has to unite with it into a triple ſalt, whilſt it does not exert the ſame action upon the ſweet muriate of mercury.

114. It is eaſy to conceive why the ſuper-oxigenated muriate of mercury, united by this proceſs with $\frac{3}{4}$ of mercury, loſes its corroſive property, ſince we have ſo many proofs that the oxigen, being proportionally diminiſhed by its diſtribution in a larger quantity of mercury to which it more ſtrongly adheres, muſt greatly diminiſh the taſte and acrimony of this compound. It is no leſs eaſy to perceive, that as the difference between theſe two ſalts depends in a great meaſure upon the quantity of oxigen being leſs abundant and more ſtrongly adhering, as alſo upon the proportion of the muriatic acid being ſmaller in the ſecond than in the firſt; whenever we ſhall combine muriatic acid with mercury but little oxidated, and it forms in its combination an inſoluble ſalt, we ſhall obtain ſweet muriate of mercury. Lemery has alſo remarked, that the ordinary white precipitate, formed by the mixture of a ſolution of muriate of ſoda with a ſolution of nitrate of mercury, required only to be ſublimed in order

to be ſweet mercury; and Neuman had likewiſe perceived a reſemblance between theſe two ſubſtances. It was upon this identity that Scheele founded the proceſs which he gave for preparing the mild muriate of mercury in the humid way. He adviſes us to diſſolve mercury in its weight of nitric acid, with the aid of a gentle heat, and to make a ſolution of a quantity of muriate of ſoda, amounting to a little more than half the doſe of mercury, in thirty-two times its weight of boiling water, to mix the two hot liquors, to keep the mixture continually ſtirring, to let the precipitate be depoſited, to decant the clear liquor that floats above it, to edulcorate it with hot water till this paſſes off inſipid, to throw the whole upon a filtre, and to dry it with a gentle heat. This muriate of mercury is as mild and as pure as that which is prepared by trituration, extinction, and ſublimation; the proceſs is ſimple, eaſy, and ſure; it has none of the inconveniences of the other, and it is greatly preferable to it.

115. The properties of the mild muriate of mercury are eſſentially different from thoſe of the corroſive muriate. It has but very little taſte, and in the ſolid form it acts only as a gentle purgative, whilſt the other is a poiſon of the moſt violent energy. Its ſpecific gravity is 12,353, according to Muſchenbroeck, who has obſerved that its ſpecific gravity was diminiſhed in proportion as it was ſublimed; it turns black by long expoſure to the light; it is luminous and

phoſphoreſcent when rubbed in the dark. It is more difficult to be volatilized and ſublimed than the ſuper-oxigenated muriate of mercury; accordingly, this riſes before the former, when mixed with it, and is found at the top in the ſubliming apparatus. When ſlowly and cautiouſly ſublimed, it yields cryſtals in tetrahedral priſms, terminated by pyramids with four ſides; ſometimes there are two quadrangular pyramids, united baſe to baſe, ſo as to form a very long and pointed octahedron. It is ſo little ſoluble, that, according to the experiments of Rouelle, made in 1754, it requires 1152 parts of boiling water for its ſolution. This ſolution turns the ſyrup of violets green, is rendered ſlightly turbid by the fixed alkalis, and aſſumes an opal colour, without forming any ſenſible precipitate when ammonia is added. It receives a brown tinge by the contact of lime-water, ammonia, and the fixed alkalis. It does not combine with the muriate of ammonia, which ſerves to ſeparate from it the ſuper-oxigenated muriate with which this laſt ſalt ſo eaſily combines. It can neither abſorb more mercury than it contains, nor exiſt in a mean ſtate of oxidation between its own and that of the ſuper-oxigenated mercurial muriate; a ſtate which ſome authors have admitted gratuitouſly, and without proofs; neither can it unite with the latter, which is eaſily ſeparated from it by volatilization; the nitric acid does not convert it into corroſive muriate; this change it undergoes only when treated with an equal weight of muriate of ſoda and twice its weight of ſulphate of iron; the addition of oxigenated muriatic acid diſſolves it inſtantaneouſly, and converts it into ſuper-oxigenated muriate. The proportions of the principles of the mild muriate of mercury are not, as yet, well known. Lemery aſſerted, that its acid was to mercury as 1 to 6$\frac{3}{9}$.

116. In compariſon with what has juſt been explained, concerning the action of the three firſt acids upon mercury, very little is known of that which the other acids exert upon it. The phoſphoric acid cannot act upon mercury, but it combines with its oxide. The only good way of effecting this combination is by precipitating nitrate of mercury with a ſolution of alkaline phoſphate; a white precipitate of inſoluble mercurial phoſphate is immediately formed: the greater part of the animal liquids yield this ſpecies of ſalt mixed with mild muriate of mercury, when nitrate of mercury is added to them. The phoſphate of mercury is phoſphoreſcent and luminous when rubbed in the dark; when expoſed to the fire, and eſpecially with a little charcoal, it yields phoſphorus. It has been pretended, that corroſive ſublimate is decompoſed in the human body by the phoſphates which it contains; but no chemical proof has been given of this aſſertion.

117. The fluoric acid exerts no action upon mercury, but it combines with its oxide, and the ſoluble fluates mixed with the nitrate of

mercury, form in it a white precipitate of mercurial fluate, the properties of which have not yet been examined.

118. The boracic acid alſo exerts no action upon mercury in a direct manner; but by mixing the ſolutions of ſoluble borates with the nitric ſolution of mercury, we obtain a yellowiſh precipitate of mercurial borate, which was firſt deſcribed by Citizen Monnet. By ſlowly evaporating the ſuper-natant liquor, a new portion of this ſalt is ſeparated in the form of ſhining pellicles. In order to obtain the borate of mercury pure, we muſt not employ the borax of commerce; for the ſoda, which this contains in exceſs, gives a portion of brick-coloured oxide of mercury which is much more acrid than the borate of mercury; we muſt, therefore, take borate ſaturated with boracic acid. The mercurial borate acquires a greeniſh colour by expoſure to the air; the muriate of ammonia renders it ſoluble and cryſtallizable; lime-water precipitates it in a red powder. It has been propoſed and adopted for medicinal uſe.

119. The carbonic acid exerts no action upon mercury, but we may combine it with its oxide, by precipitating its ſolutions in the other acids by means of the alkaline carbonates. Theſe carbonates are white or but little coloured; they do not acquire a deeper tinge by expoſure to the air, like thoſe which have been made by the pure or cauſtic alkalis. However, they aſſume a brown tinge in drying, and it is on

account of this tinge, which the oxide of mercury, formed by the action of fire alone, ſometimes aſſumes as it cools in the air, that this oxide is ſuppoſed to be charged at that time, or in the caſe of its acquiring the brown colour, with carbonic acid. This compound is not ſoluble in water; the preceding acids expel the carbonic acid from it in the form of gas with efferveſcence.

120. The combinations of the four known metallic acids with the oxide of mercury have not yet been accurately examined; it is only known that theſe acids in general exert but very little action upon mercury, ſince this metal cannot abſorb oxigen from them. Scheele has indicated ſome of the properties of the arſeniate, tungſtate, and molybdate of mercury, which are prepared by pouring into the nitric ſolution of this metal alkaline or ſoluble ſalts formed by theſe acids.

A. The arſenic acid, treated in a retort with mercury, is partly decompoſed by this metal; arſenious acid, running mercury and a ſmall quantity of yellow oxide of mercury are ſublimed; there remains in the retort a yellow maſs, not fuſed, inſoluble in water and in the ſulphuric and nitric acids, ſoluble in the muriatic acid, and yielding afterwards, by the evaporation and ſublimation of this ſolution, ſuper-oxigenated muriate of mercury and fuſed arſenic acid; the mercury decompoſed a part of this acid by depriving it of a portion of its oxigen, and leaving it that which forms the arſenious acid; the oxide of mercury that was formed united with the other portion of this acid into an arſeniate of mercury, which the muriatic acid then decompoſed, and in the mercury of which it found a ſufficient quantity of oxigen to change it to the ſtate of corroſive muriate.

B. The arſenic acid precipitates the ſulphate and the nitrate of mercury of a white colour; it decompoſes the mild mercurial muriate, and converts it into corroſive muriate; it produces no effect upon the latter, nor upon the oxide of mercury.

C. The tungſtic and molybdic acids precipitate the nitric ſolution of mercury of a white colour; it appears that the tungſtate and molybdate of mercury are white and inſoluble.

D. The chromic acid, combined with the oxide of mercury by the addition of the ſolution of an alkaline chromate with that of the nitrate of mercury, forms an inſoluble precipitate of a very lively and brilliant purple colour, which Citizen Vauquelin, who diſcovered it, thinks might become of great utility in painting.

I. *Action upon the Alkaline Baſes and the Salts.*

121. MERCURY is not ſuſceptible of alteration by the alkaline earths and the alkalis. In the experiments of Weſtendorf and Wallerius upon this metal, pretended to be combined with the

fixed alkalis by fuſion in crucibles, it appears that they miſtook the union of an oxide of iron with thoſe baſes for that of the mercury, which, in reality, does not ſuffer any alteration.

122. The caſe is not the ſame with the oxides of mercury; beſides the fact, that ſeveral of them are ſuſceptible of combining with the alkalis in general, and of forming with them compounds in which theſe oxides ſeem to act the part of acids, ammonia exerts upon thoſe burned ſubſtances a very remarkable action, which has already been indicated in the account of the precipitations of the mercurial ſalts, but which ought again to be conſidered in this place. We have already ſeen, that ammonia poured upon the white, yellow, and red oxides of mercury, turns them black, produces an extrication of azotic gas with noiſe and effervefcence, and that this is owing to the reciprocal decompoſition of theſe two ſubſtances, which form water by the union of the hidrogen of the ammonia with the oxigen of the oxide, whilſt the azote, having become free, is diſengaged in the form of gas: but there is another chemical effect which a circumſtance led me to diſcover in this action. I had remarked, that the effervefcence and the extrication of azotic gas were but little ſenſible, and did not appear to accord with the proportion of reduced oxides. I therefore examined the product of this operation with greater attention; and by evaporating the

lixivium of a mixture of red oxide of mercury and of ammonia in exceſs, which had in part effected its reduction, I obtained a real triple ſalt, an *ammoniaco-mercurial nitrate:* nitric acid is conſequently formed by the effect of this decompoſition. The oxigen of the oxide of mercury divides itſelf between the two principles of the ammonia: one portion forms water with its hidrogen, another conſtitutes with its azote, nitric acid, which, uniting with a part of the oxide, and of the ammonia that have not been decompoſed, gives riſe to the ammoniaco-mercurial nitrate which is obtained. This phenomenon accords with that which takes place when we cauſe ammoniacal gas to paſs into a red hot tube containing oxide of mangane ſe: it recurs alſo in the decompoſitions of the ſulphates of mercury by ammonia, in which we always meet with a ſmall quantity of ammoniaco-mercurial nitrate, when we examine the products of the experiment with attention. The property which ammonia poſſeſſes of ſpeedily reducing the oxides of mercury, ſuggeſted to me the idea of employing it for cleaning and purifying, in ſome degree, the ſurfaces of the hidrargyro-pneumatic veſſels. When the mercury has been ſoiled and oxidated by the ſaline gaſes, and eſpecially by the oxigenated muriatic acid gas, I reſtore it to all its natural luſtre and purity by pouring and moving ammonia upon its ſurface, by the aid of filtering paper, upon which it immediately aſſumes its uſual brilliancy and colour.

123. Mercury and its oxides exert no action upon the earthy and alkaline ſulphates, nitrates, phoſphates, nor upon any other kind of ſalts, if we except the muriates. It has already been obſerved, that Citizen Monnet had indicated the decompoſition of the muriate of ſoda by the oxide of mercury, and the formation of corroſive muriate of mercury. Lagaraye, in a kind of empirical medicinal preparation, has even ſucceeded in decompoſing the muriate of ammonia by means of running mercury, as Macquer aſſured himſelf by a ſcrupulous examination of the proceſs for his *mercurial tincture.* Lagaraye triturated one part of running mercury with four parts of muriate of ammonia in a marble mortar, moiſtening the mixture with a little water till the extinction was complete; he afterwards expoſed the mixture for ſeveral weeks to the air, agitating it from time to time; he triturated it a-new, and heated it then in a matraſs with ſome good alcohol, which he even cauſed to boil ſlightly; the alcohol aſſumed a yellow colour, and it whitened a plate of copper. Macquer was convinced that this liquor contained ſuper-oxigenated muriate of mercury in ſolution, that by the operation of time, the muriate of ammonia had been decompoſed by the mercury which had become oxidated, and that a ſpecies of ammoniaco-mercurial muriate or *Sal Alembroth* had been formed.

K. *Uſes.*

124. There are few metallic ſubſtances that exceed mercury in utility. In phyſics it is employed, in its metallic form, in the conſtruction of meteorological inſtruments, and a great number of machines; in the arts, it is employed, in the ſame form, for gilding, ſilvering of glaſs mirrors, and in metallurgical operations: its ſolutions are uſed in dyeing.

125. In chemiſtry, it is applied to a great variety of uſes, all equally important. Beſides the experiments in which it is employed for demonſtrating the principal truths of this ſcience, it has become of indiſpenſable neceſſity for furniſhing the veſſels deſtined to collect, preſerve, and combine the elaſtic fluids of a ſaline nature. Theſe apparatuſes are termed hidro-pneumatic veſſels. It is no leſs uſeful for luting or cloſing moveable tubulatures, for producing compreſſion. Lavoiſier had already attempted to uſe it for ſupplying the place of the lutes, by means of which, the veſſels are cloſed, and which ſo frequently occaſion inconvenience, error, and inaccuracy in experiments. It is of great utility to anatomiſts in their moſt delicate and difficult injections, ſuch as thoſe of the lymphatic and abſorbent ſyſtems in all animals, and of the tracheal ſyſtem of inſects and worms.

126. It is of equal importance for medicinal purpoſes. Since its ſalutary effects in cutaneous

diſeaſes, and its ſpecific operation in ſyphilitic affections have been known, it has been exhibited in a great variety of forms and preparations. As theſe properties were attributed to the metal itſelf, endeavours were made to ſoften or modify it; but ſcarcely any thing more was done, than, on the contrary, to give it, unknowingly, a greater degree of activity, by combining with oxigen, which is the true cauſe of its effects. In general, mercury ought to be conſidered, in its medicinal preparation, as nothing more than an oxiphorous ſubſtance, as a ſubſtance which carries oxigen into the animal economy, which readily imparts it to the fluids and ſolids, and the varieties of theſe preparations under the relation of the quantity of this principle which they contain. The leaſt oxidated compounds have but little activity: ſuch are the black oxides of mercury which are prepared in the numerous proceſſes of extinction, by the addition of mucilages, ſyrups, honey, jellies, or animal humours, ſuch as ſaliva, the fats.

In a ſecond claſs are to be ranked the mercurial ſalts, of little ſolubility, the oxide of which, being either but little oxidated, or in ſome reſpect confined by acids, does not nearly exert all its energy upon the animal fibre or humours: ſuch are the mild mercury, the carbonate, the borate, and the phoſphate of mercury.

In a third claſs we are to rank the oxides of mercury united with ſulphur, either black, or red, which act but ſlightly, or only when in the form of vapour upon the animal economy.

Laſtly, a fourth claſs of theſe mercurial remedies is formed of oxides the moſt highly charged with oxigen, either alone or combined with the acids; ſuch as the different precipitates, yellow, white, red, and the ſuper-oxigenated ſulphate, nitrate and muriate of mercury. Theſe are violent cauſtics; they burn and deſtroy the organs; they are employed externally as detergents, and internally as powerful remedies which muſt be adminiſtered with great prudence, and which only the ſkilful practitioner ſhould be permitted to employ, with that circumſpection which ought to diſtinguiſh the true phyſician.

127. What proves that the action of the mercurial preparations is owing to the oxigen which they contain, to the ſeparation of this principle, and its being transferred to the organs, and the humours of animals, is that the oxides of which they conſiſt, become black, and are reduced in the internal part of the body, and that running mercury is frequently found in the internal cavities of the body, in the lymphatic ſyſtem, and in the bones, themſelves, after a mercurial courſe of a longer or ſhorter duration.

123. What I have here been able only to announce and preſent to the reader in general terms, has been very fully treated in the treatiſe of my friend Dr. Schwediauer, a work

the moſt complete, the moſt original, and the moſt philoſophical that has yet been publiſhed concerning the ſyphilitic affections. Several chapters of this excellent work exhibit all the new facts which I have preſented for ſeveral years paſt, relative to the properties of this medicine as an oxipherous remedy; data which this able phyſician has confirmed by his own obſervations. It concludes with a methodical table of theſe preparations, intitled *pharmacopoeia ſyphillitica:* where the reader will ſee how well the author has availed himſelf of the preſent ſtate of chemical knowledge in the claſſification of theſe remedies.

ARTICLE XV.

Of Zinc.

A. *Literary Hiſtory.*

1. ACCORDING to Bergman, zinc was not known to the ancients. Paracelſus is the firſt chemiſt who has treated of it, and who gave it the name which it bears. Agricola has ſince termed it *contre-feyne*, and Boyle, *ſpeltrum*. Albertus Magnus, who died in the year 1280, makes very diſtinct mention of it; he knew that it was combuſtible, and inflammable, and that it coloured metals. It ap-

pears that zinc has for a long period back been extracted from its ores in the Eaſt Indies, as was firſt obſerved by Jungius in the year 1647. It is brought from thoſe parts under the name of *tutenague*. Without being particularly acquainted with it, and diſtinguiſhing it accurately from other metals, the Greeks ſeem alſo to have employed it, as it is ſaid to have conſtituted a part of the famous Corinthian braſs.

2. It is not known by what proceſs the Chineſe obtain this metal, which they employ in a great number of alloys: it is believed, that they extract it by diſtillation. Henckel aſſerted, in 1721, in his Pyritologia, that zinc might be extracted from calamine. In 1742, Schwab extracted it by diſtillation. Margraff occupied himſelf with this extraction in 1746.

3. Lemery conſidered zinc as a ſpecies of biſmuth. Glauber, with the alchemiſts, conſidered it as an immature ſolar ſulphur; Homberg took it for a mixture of iron and tin; Kunckel, for coagulated mercury; Schlutter, for tin rendered brittle by ſulphur. In ſhort, it is not more than fifty years ſince it has been known to be a metal, *ſui generis*, pure, well characterized, and different from all other metals.

4. The chemiſts whom I have juſt quoted, as well as all thoſe whoſe works have embraced the whole or entire ſyſtem of natural bodies, have ſucceſſively examined zinc and dif-

diſcovered its properties. Hellot, Pott, Malouin, Laſſone, Monnet, Baumé, Bergman, are thoſe who have ſucceſſively inſtituted particular inveſtigations reſpecting this intereſting metal. Gellert has treated of its alloys; Malouin has compared it with tin; Bergman has given an extenſive and very detailed docimaſia of its ores. Citizen Sage, firſt aſcertained its ductility; Dehne, and Citizen Guyton, have particularly directed their attention to its combination with ſulphur. Gaubius has aſcertained ſeveral of the properties of its oxide; Macquer has dwelt upon its economical uſes; Pelletier has accurately deſcribed its union with phoſphorus.

5. Since the revolution and renovation of chemiſtry, effected by the doctrine of the French, no new reſearches nor conſecutive ſeries of inveſtigations have been made reſpecting zinc; nevertheleſs the exact data and baſes of this doctrine have rendered our knowledge of the chemical properties of this metal much more clear and preciſe; ſo that its hiſtory is much more eaſy and more methodical than it was previous to this period, and all the facts which appertain to it, are linked together by much more intimate relations, than they had been during the reign of the theory of phlogiſton.

6. It will however appear, from the details which will form the ſubject of this article, that all which relates to zinc is not yet entirely and completely diſcovered, that many

diſcoveries ſtill remain to be expected, and that it may ſtill afford a ſubject to able chemiſts for valuable reſearches, eſpecially with the new inſtruments which we now poſſeſs.

B. *Phyſical Properties.*

7. Pure zinc is of a brilliant white colour, with a blueiſh tinge, which is very perceptible in its metallic ſtate, preſenting a very diſtinctly lamellated texture, the laminæ of which, are, however, not ſo broad as thoſe of biſmuth and antimony. When we place it beſide theſe two metals, we perceive the marked difference of its colour. Its denſity is ſuch, that it loſes in water about a ſeventh part of its weight, and weighs 7,190. It is ſufficiently hard and elaſtic not to break ſo eaſily as any of the metals which have hitherto been treated of; accordingly, I have placed it in the third diviſion of the metals poſſeſſing conſiderable ductility.

8. In fact, zinc is not brittle, like the preceding metallic ſubſtances. It requires a violent and ſudden ſtroke to break the flat plates, or blocks of it, ſuch as we meet with in commerce; and when it is in thick ingots, we are obliged, in order to vend it in fragments, to cut it with iron wedges, ſtruck into it by means of heavy hammers. When it is hammered upon a ſteel anvil, it becomes flattened inſtead of breaking: it is reduced into thick plates, which do not crack till after they have been very conſiderably flat-

tened. It may be extended, without breaking, into pretty thin plates, by paſſing it through the flatting-mill with an even and gradual preſſure: theſe plates are flexible and elaſtic, but very far from exhibiting the ſoftneſs and pliability of thoſe of the ſoft metals.

9. Its tenacity, however, is but weak. Files act upon it with difficulty; it adheres to the interſtices between their teeth, ſo as to clog them, to uſe the expreſſion of the artificers. Accordingly, when we wiſh to procure it in minute fragments, deſtined for a great number of experiments, we are obliged to divide it by pounding, or by pouring it fuſed into water. Macquer obſerves, that it becomes brittle, and that we may pulverize it in a mortar, if we heat it to a degree ſhort of that which fuſes it. The beſt proceſs which we can employ for pulverizing zinc, conſiſts in fuſing it, and pounding it in a heated ſtone mortar, ſo as to divide its molecules, to prevent their re-uniting and ſtriking together whilſt they are cooling, and to keep them ſeparate at the moment when they become fixed. When it has cooled, it is paſſed through a hair-ſieve, which by retaining the groſſer particles, affords a powder of zinc, which it finer than moſt of the filings of metals.

10. The conducting power of zinc, with reſpect to caloric, has not been determined: all that is known is, that it is heated very quickly, and that it dilates readily, and to a great degree. It fuſes as ſoon as it becomes red-hot,

in which reſpect it is ranked amongſt the metals of a middling fuſibility. Citizen Guyton eſtimates this property at 296 degrees of Reaumur's ſcale. If we continue to heat it, after its fuſion, in cloſe veſſels, it riſes into vapour, and ſublimes, attaching itſelf in a brilliant, metallic, and lamellated form to the upper part of the veſſels. If we let it cool quietly after it has been fuſed, it cryſtallizes into needles, which are generally very fine, the form of which has not been determined. The unfortunate mineralogiſt, Mongez, the elder, who was loſt with La Peyrouſe in his voyage round the world, is the firſt who cauſed this metal to cryſtallize; he fuſed it for this purpoſe in a pretty deep earthen veſſel, perforated with ſeveral holes at the bottom, which he ſtopped up with earth of bones. When the zinc which he fuſed in this veſſel was fixed at its ſurface, he opened the holes, introduced a red-hot iron, which he ſtirred in the maſs of the metal, and thereby cauſed the portion, which was ſtill liquid, to run out, after which he found cryſtals, ſhaped like needles, in the cavities which it had left.

11. Zinc is a conductor of electricity like all the metals, and nothing particular has hitherto been diſcovered in it with reſpect to this property; however, the powerful manner in which it affects the ſenſibility of the human body in Galvanic experiments, ſeems to give it herein a ſort of prerogative or pre-eminence over other metallic ſubſtances. If we place a plate of

zinc under the tongue, and cover the upper ſurface of this organ with another metal, and eſpecially a piece of gold or ſilver, and then incline the extremity of this laſt ſo as to approach it to the plate of zinc; at the moment when the two metals come into contact with each other, the perſon who performs the experiment, feels a very perceptible pricking ſenſation, heat, irritation, and a ſort of acerb taſte in the tongue, almoſt always accompanied with a momentous glare, or a luminous circle, which ſuddenly appears before his eyes. No metal produces this ſingular effect with ſuch force as zinc is obſerved to do.

12. We alſo find in this metal a ſlight odour and a peculiar taſte with which the fingers become impregnated when they are kept for ſome time applied to this metal or rubbed upon it. Though theſe two properties are eaſily and unequivocally recognized as being metallic, and though, in this reſpect, they reſemble thoſe which are found in ſeveral other metals, it cannot however be doubted that they are not the ſame in zinc as in other metallic ſubſtances. Zinc alſo adheres ſtrongly to the ſkin, and tinges it black. This is a metal which is ſurrounded with one of the moſt perceptible metallic atmoſpheres, and which applies itſelf the moſt quickly, and by the ſlighteſt contact to all the ſubſtances upon which it is rubbed. Thus, for example, we need only draw a plate of zinc over a plate of iron, ſilver, or lead, in order to

give theſe metals the power of acting in galvanic experiments, as if they were other metals than what they really are, namely of producing, by communication with plates of the ſame kind, convulſions in the muſcles of frogs; which ſhows that their ſurface is covered with a layer of zinc, which performs the function of a different metal.

C. *Natural Hiſtory.*

13. Several mineralogiſts have thought that zinc is one of the moſt abundant metals in nature, and that it conſtantly accompanies the ores of iron; but though the ores of zinc are in conſiderable plenty in various countries, yet their abundance is very far from being comparable to that of the ores of iron; and beſides, it is at preſent well aſcertained that the metallic ſubſtance that is ſo often mixed with the iron is only oxide of manganeſe, which the ſame mineralogiſts have long miſtaken for zinc.

14. Citizen Haüy, the laſt, the moſt learned, and moſt accurate author on Mineralogy, enumerates only three ſpecies of ores of zinc, namely, its native oxide, its ſulphuret, and its ſulphate. Valmont-Bomare ſays, he has ſeen in the ores of Goſlar, and in thoſe of the Duchy of Limbourg, which are very fertile in this metal, native zinc which is found in ſmall pliable filaments, of a greyiſh colour, and eaſily inflammable.

mable. This obſervation has not been confirm-by other naturaliſts. Some authors admit native carbonate of zinc, and ſome think there are reaſons to doubt its exiſtence, but we ſhall ſoon ſee that this ſalt does really exiſt in nature. Frequently the ores of zinc are mixed with ores of lead, iron, and manganeſe; but we have here only to enumerate thoſe in which zinc is the moſt abundant metal.

15. The oxide of zinc, or oxidated zinc, forms the calamine of the ancient mineralogiſts. This ore of ſecondary formation depoſited in layers, either in a regular form, or in incruſtations and ſtalactites in the interior of the earth, has generally preſented only very ſmall cryſtals, ſemi-tranſparent, whitiſh, and of an unctuous aſpect, eaſy to be recognized; their moſt common form is that of a rectangular lamina, the edges of which are replaced by facets or ſegments of cuneiform octahedrons, or an elongated quadrangular pyramid projecting out of its gangue. This form is alſo found in the ſulphate of barites. The cryſtals of native oxide of zinc preſented to Citizen Haüy the property of becoming electric by the action of heat without friction, like the tourmaline. The heat of a lighted taper applied to them for two or three ſeconds is ſufficient to exhibit this property. I ſhall here obſerve, with the celebrated mineralogiſt to whom we owe this diſcovery, that five minerals are already known which poſſeſs this property; three ſtones, the tourmaline, the

topaz,

topaz, and the zeolite; one ſalt, the native magneſio-calcareous borate, and the foſſil cryſtallized oxide of zinc.

The oxide of zinc is frequently in irregular maſſes, foliated, cavernous, granulated, hard or friable. It is found of different colours, and eſpecially grey and yellowiſh, even amongſt the tranſparent ſpecimens. It exiſts in abundance near Limberg, Namur, Friburg, and in the counties of Nottingham, and Somerſet. Bergman has alſo found it to contain ſilex, alumine, and oxide of iron in different proportions. The zinc varies in it from 0,04 to 0,30.

According to Citizen Haüy, the modern mineralogiſts, in diſtinguiſhing calamines containing carbonic acid, or native carbonates of zinc, have been guilty of errors, and even of contradictions, for ſome arrange them improperly amongſt the oxides; others, on the contrary, claſs amongſt them oxides in which an exact analyſis has not found this acid. Such is the native oxide of zinc of Briſgau, examined by Pelletier, which Deborn ranges in the ſpecies of carbonate of zinc. By treating fragments of this ſame oxide, which had been procured from different places, with nitric acid, Citizen Haüy has obſerved no effervefcence; he has obſerved that the earthy powders which frequently envelop them, diſſolve in it with an extrication of bubbles, and he is thence led to believe, that the effervefcence is owing to the carbonate of lime mixed amongſt the native oxide of zinc. I ſhall ſhortly prove that there really exiſts a native carbonate of zinc.

16. The ſulphuret of zinc, or ſulphurated zinc, has been termed *Blende,* or Falſe Galena, by the mineralogiſts. It is frequently diſpoſed in ſcales, ſometimes cryſtallized in tetrahedrons, in octahedrons, in dodecahedrons. Its colour is ſometimes yellow, like honey, frequently metallic, and analogous to that of lead, or brown, deep violet, and even black, often reddiſh. It is frequently found mixed with the ſulphuret of lead or galena, with which it ſeems to form a kind of metallic brechia. Before the nature of the metal contained in this ore was known, it was termed *Sterile Nigrum,* becauſe, with the appearance of an ore of lead, none could be extracted from it by the metallurgical proceſſes; the zinc, which was not at that time ſuſpected to exiſt in it, exhaling in the form of vapour. Many of the ſulphurets of zinc are more or leſs phoſphoreſcent when rubbed in the dark; ſome are even ſo ſtrongly ſo, that, by merely rubbing them with a tooth-pick, we cauſe torrents of light to be emitted; they exhale an hidro-ſulphureous ſmell, and yield ſulphurated hidrogen gas when treated with the acids. Their nature is not well known; it is not aſcertained whether the zinc exiſts in them in the metallic ſtate, or in that of oxide; whether it be united with the ſulphur alone, or whether there are one or more other bodies which

ſerve as intermediums. Some chemiſts have ſuppoſed iron, and others lime, to exiſt in them. The following are the principal varieties that have been diſtinguiſhed, of the ſulphuret of zinc.

a. Dodecahedral ſulphuret of zinc, with planes in the form of rhombuſes: a form which is obtained from the maſſes of ſulphuret of zinc by neat ſections. It has always additional facets.

b. Sulphuret of zinc, with twelve trapezoids and twelve triangles.

c. Sulphuret of zinc in a regular octahedron.

d. Sulphuret of zinc in a regular tetrahedron.

e. Sulphuret of zinc; numerous varieties of colour.

f. Sulphuret of zinc phoſphoreſcent and non-phoſphoreſcent.

g. Sulphuret of zinc in decompoſition, laminæ ſeparated, its luſtre deſtroyed, paſſing into the ſtate of oxide.

17. The ſulphate of zinc is found in a native ſtate, and is very eaſy to be diſtinguiſhed by its whiteneſs and tranſparency, its acrid and ſtrong taſte, its ſolubility in water, its aqueous fuſion. It is rarely found in the earth in rhomboidal cryſtals, but moſt frequently in ſtalactites or in fine needles, and ſilky filaments, reſembling thoſe of the amianthus; in the latter ſtate it has often been confounded with the plume-alum. It is found in Italy, and in the mines of the Hartz.

18. The native carbonate of zinc, which is uſually confounded with the oxide of zinc or calamine, is tranſparent, white or yellowiſh like that ſubſtance ; it is frequently found in the ſame places. Citizen Vauquelin has examined a very pure ſpecimen of it in the mineralogical collection of Citizen Macquart. This ſalt, which is inſipid and inſoluble in water, diſſolves entirely, and with a lively effervefcence in the nitric and muriatic acids.

D. *Aſſay and Metallurgy.*

19. THE docimaſtic aſſay of the ores of zinc, that at leaſt which was conſidered as applicable to the metallurgic knowledge of its nature was very ſimple and very inaccurate. It conſiſted in pulverizing the oxides of this metal, or its calamines, mixing them with charcoal, and heating this mixture in a crucible which was covered with a plate of copper. The oxide was reduced into zinc, which was volatilized by the heat and united with the copper, and converted it into braſs or yellow copper. The richneſs of the ore was judged of, according to the force or intenſity of the white colour; but it is evident, that this rude aſſay could only ſerve, on the one hand to aſcertain the exiſtence of an ore of zinc, and on the other to prove that this ore was capable of converting copper into braſs. The ſulphurets of zinc were roaſted in order to ſeparate the ſulphur from them, and

the reſidue of this roaſting was treated in the ſame manner as the calamines.

20. Citizen Monnet was the firſt who propoſed to make the aſſay of theſe ores by means of the nitric acid, the action of which, he thought, ought to diſſolve the metal and ſeparate the ſulphur from it, and afterwards to reduce the oxide of zinc ſeparated from the acid by diſtillation. Bergman, however, has greatly extended and improved the proceſſes of this analyſis by the humid way. He employed ſulphuric acid in order to analyze the oxides of zinc; he precipitated theſe oxides by means of the carbonate of ſoda; and he found that 193 parts of this precipitate repreſented 100 parts of metal. As he employed zinc in order to ſeparate the ſolution of iron, which is often mixed with theſe ores, he ſubtracted from the weight of the precipitate the quantity of metal employed in this operation. As the greater part of the native oxides of zinc contain more ſubſtances than iron and zinc, and eſpecially alumine, ſilex, carbonate of lime, with the oxides of iron and lead; the following is the method which he has deſcribed in order to proceed with accuracy in the analyſis of theſe complicated ores. The pulverized oxides are treated three ſucceſſive times with two parts of nitric acid; heat is afterwards applied till the whole is reduced to dryneſs: by this means the iron is highly oxidated, and becomes inſoluble in the acids. He diſſolves the ſoluble part by means of a

fourth doſe of nitric acid: the oxide of iron, the ſilex and the alumine remain together without being taken up. The acid holds in ſolution lime and the oxides of zinc and lead. The laſt oxide is precipitated by the muriatic acid; the lime is ſeparated by the ſulphuric; the oxide of zinc is precipitated by the pruſſiate of pot-aſh: and the fifth part of the weight of the laſt precipitate indicates the proportion of the zinc. He has alſo employed ſulphuric acid heated to dryneſs, lixiviated the reſidue with water, and precipitated this lixivium by means of ammonia, in order to ſeparate the oxide of iron and the alumine from the oxide of zinc, which is very ſoluble in this alkali.

21. As to the ſulphurets of zinc, Bergman, who has alſo examined them much in detail, deſcribes, in his Diſſertation on the ores of this metal, the method which he has followed in order to effect their analyſis. He firſt ſeparated from them, by diſtillation, the water, the arſenic, and a portion of ſulphur; he afterwards treated them with different acids, according to their degrees of ſolubility in theſe ſubſtances, and precipitated them by means of the different reagents known in the art, of which I have already had frequent occaſion to ſpeak. He found ſuch great differences between the various ſulphurets of zinc from different countries, that the ores ſeem to poſſeſs no general or identical properties and compoſition. There is, however, reaſon to believe, that theſe operations

are as yet far from having been brought to perfection, and that it is neceſſary that able chemiſts ſhould ſtill employ themſelves upon them. Important diſcoveries ſtill remain to be made, as well upon the ſulphurets of native zinc, as upon the different ores of this metal. Thus, by reducing a pulverized calamine in cloſe veſſels, Citizen Vauquelin obtained hidrogen gas holding zinc in ſolution, and proved, as I had long ſuſpected, eſpecially with regard to arſenic, tin, and iron, that various metals are ſoluble in that inflammable gas, like carbon, phoſphorus and ſulphur.

22. The ores of zinc are rarely worked by themſelves, or with the ſole intention of extracting this metal. It will be remembered that I remarked above, that their particular treatment, and the extraction of zinc was not ſpoken of till towards the commencement of the eighteenth century. It is moſt frequently by fuſion of the ores of lead mixed with ſulphuret of zinc, that the latter metal is obtained in two forms; in that of oxide of zinc, proceeding from the zinc which has been ſublimed and burned during its ſublimation, which attaches itſelf to the chimnies of the furnaces, where it forms incruſtations of a grey colour, granulated, as it were earthy, which are known in metallurgy and in commerce by the names of *Tutty*, or *Cadmia* of the furnaces;—and in that of metal which is obtained by moiſtening with cold water the anterior part of the furnace, which is

thinner at this place, and which is termed *chemiſe* in metallurgical language. The zinc, being reduced to vapour by the action of the fire, condenſes itſelf at this place, and falls back in the form of ſmall grains into the pulverized charcoal, which is ſtrewed upon a ſtone placed at the bottom of the chemiſe, and termed, on account of its uſe, the zinc-plate *(l'aſſiette du zinc)*. The charcoal preſerves the metal from being oxidated; it is afterwards fuſed a ſecond time in a crucible; it is then caſt into ingots rounded on one of their ſides, or into plates ſeveral centimetres in thickneſs, and ſeveral decimetres in length or breadth. This proceſs is chiefly practiſed at Rammelſberg, from whence the commerce of France is particularly ſupplied with this metal.

23. The art of extracting zinc in the large way is capable of receiving a great degree of perfection, and will gain much by being more ſtudied than has hitherto been done. We are utterly ignorant of the proceſſes employed by the nations of the Eaſt, and particularly the Chineſe, who make much greater uſe of this metal in their alloys, than moſt of the European nations. A great number of the Chineſe wares are wrapped or incloſed in leaves or veſſels of a ſoft alloy, poſſeſſing a greater or leſs degree of reſiſtance, grey, a little oxidated at its outer ſurface, frequently carved or moulded in different ways, and in which zinc is one of the moſt abundant principles. It is brought to us

from this nation, amongſt whom induſtry has ſo highly flouriſhed during a great number of ages, under the name of *Tutenague,*—a much purer ſpecies of zinc than that of Rammelſberg, which always contains lead. In 1775, Mr. Engeſtroem made the analyſis of a brittle calamine of China, which Mr. Kirwan terms *Tutenague*, in his mineralogy, and which contains from 0,60 to 0,90 of zinc. It is from a ſimilar ore that the Chineſe extract their zinc, though we are not acquainted with the proceſs which they employ for that purpoſe. Some mineralogiſts aſſert, that zinc is extracted in England, from its native oxide by diſtillation or ſublimation; though neither the means nor the apparatus uſed in this important operation are hitherto known.

E. *Oxidability of Zinc by the Air.*

24. Zinc ſuffers only a very ſlow, and a very ſlight alteration by the action of cold air; its luſtre is a little tarniſhed, and in the courſe of time it becomes covered with an extremely thin layer of grey oxide; that alſo which is ſeen upon the blocks and the ingots of commerce is not produced except when this metal, being poured out into open veſſels, has been very hot, and expoſed for ſome time to the atmoſpherical air, whence it has taken a ſmall quantity of oxigen which has oxidated its ſurface. When zinc, fuſed in cloſe veſſels, is ex-

poſed to hot air, at the moment when it begins to become fixed, it aſſumes blue, yellow, and brilliant roſy tinges, which reſemble thoſe of the rainbow. This is a commencement of oxidation.

25. When zinc is fuſed in contact with the air, the temperature not being raiſed higher than is requiſite to melt it, or at leaſt, not much higher, its ſurface acquires rainbow colours, becomes wrinkled, loſes its brilliancy, and ſoon aſſumes a dirty grey colour. When we take away this portion which forms a pellicle, a ſecond is formed ſimilar to the firſt, which being ſeparated in its turn, is replaced by a third; and the whole zinc is ſuſceptible of being changed in this manner to the laſt layer. This grey oxide is formed much more quickly, when we agitate the fuſed metal conſiderably and cauſe it to touch the air in many of its points. By heating the grey clots which are thus obtained in contact with the air, they gradually divide themſelves, and become an uniform grey powder, which at laſt aſſumes a dirty yellowiſh colour. The oxidation of the zinc cannot then be carried farther by this proceſs. The yellow oxide that has been formed in this manner weighs about ſeventeen parts more than the zinc in the hundred parts of the latter. It is eaſily reduced into zinc by the action of ignited charcoal; when a very ſtrong heat is applied, it is fuſed into a yellow glaſs.

26 When zinc is ſtrongly heated in a crucible, ſo as to render it of a bright red; and when after having opened this veſſel, we agitate the zinc thus ignited to redneſs and almoſt raiſed to the point of volatilization, it ſuddenly kindles and emits a flame of a white colour with a ſlight greeniſh tinge, which is extremely brilliant, and by ſtrongly illuminating all the ſurrounding objects, preſents a very beautiful ſpectacle. Amongſt all the metals this burns with the moſt ſenſible flame, and at the loweſt temperature. As this rapid combuſtion, this deflagration, which has been compared with juſtice to that of phoſphorus, on account of its luſtre, its vivacity, its colour, as well as the ſtrong heat which accompanies it, takes place at the moment when the zinc in converted into vapour, and partly in the vapour itſelf, the oxide of zinc which is ſuddenly formed, and which produces in the air a white, odorous and acrid ſmoke, the ſenſation of which particularly affects the fauces, is condenſed in the atmoſphere in flakes, and in a kind of filaments of a beautiful white colour, very light, and of a very delicate texture, much reſembling thoſe light filaments produced by an inſect which is wafted along with the wind in the ſpring and autumn. This oxide formed in the air has been termed *flowers of zinc, pompholix, nihil album, philoſophical wool or cotton.*

27. The ſublimed oxide of zinc, *oxidum zinci ſublimatum*, is entirely ſaturated with oxigen; it contains much more of it than the grey and yellow oxide of which I have ſpoken No. 24, ſince it is the product of a much ſtronger combuſtion, and it ſtands in the ſame relation to this firſt oxide as the phoſphoric to the phoſphoreous acid. Some modern chemiſts think it contains more than half the weight of the zinc in oxigen, and Citizen Guyton makes the proportion of this principle amount to 0,61. It is not volatile by itſelf. It emits for ſome time after it has been prepared, a phoſphoric light. It is irreducible, and the action of the ſtrongeſt fire does not cauſe it to give out any of its oxigen, but fuſes it into a glaſs of a very pure yellow colour. The oxigen exiſts in it in a ſtate of great condenſation and fixity. Even with the addition of carbon, it is not reduced but with difficulty, and a very high temperature; and this operation ſucceeds only in cloſe veſſels. It ſublimes during its reduction. The hidrogen contained in the charcoal, and diſengaged by the action of the fire during this reduction, carries away with it a portion of zinc which renders it ponderous, with the property of burning with a brilliant flame and a depoſition of oxide. In general, this oxide of zinc retains the oxigen which is combined with it with much obſtinacy, and no metal can take it away from it. It would be very uſeful to

examine it by all the means which the ſcience in its preſent ſtate affords; for it promiſes important diſcoveries.

F. *Union with the Combuſtible Subſtances.*

28. No combination is known between azote and zinc, nor between this metal and hidrogen; the latter ſubſtance diſſolves metallic zinc and raiſes it in the form of gas under certain circumſtances; but this gas reduces the oxide of zinc at a high temperature. Neither is there any known combination of carbon and zinc; though a ſmall quantity of carbon is frequently extracted from this metal; but as the carbon which is ſeparated from it is combined with iron, it is thought that this laſt metal has in ſome manner introduced it into the firſt. We ſhall ſoon return to this fact.

29. Phoſphorus combines very well with zinc with the aid of heat. Margraff had only ſeen the union of its oxide with this combuſtible body, and obtained it in a ſublimate of an orange-red colour. Pelletier, who has made many experiments upon this combination, has obſerved the ſame compoſition in red ſublimate; but he has carefully diſtinguiſhed from it the phoſphuret of zinc, which he has made, either by heating zinc with phoſphorus in a crucible, or by diſtilling theſe two ſubſtances

in a retort, or by decompoſing vitreous phoſphoric acid by charcoal and adding zinc filings to this mixture. The proceſs which he has found moſt ſucceſsful conſiſts in throwing phoſphorus upon zinc heated to redneſs in a crucible. In this manner he has obtained a phoſphuret of zinc of a metallic appearance, leſs white than the zinc, and even of a leaden grey colour, which extended itſelf a little under the hammer, diffuſed a phoſphoric adour on the application of fire, and left a ſpongy reſidue. He obſerves, that by heating zinc and phoſphorus in a retort, part of the metal is always oxidated, and that on this account we obtain a red ſublimate which has already been mentioned; he aſcribes this effect to the water, of which, according to him, it is very difficult completely to deprive it.

30. Zinc cannot be combined with ſulphur in a direct manner: when thoſe two combuſtible ſubſtances are heated together in a crucible, the ſulphur ſeparates without uniting with the zinc, which only becomes a little more infuſible. Mr. Dehne has obſerved, that when theſe two ſubſtances are kept together in the ſtate of fuſion in a crucible, the zinc becomes oxidated, and then unites with the ſulphur, aſſuming a brown or grey colour. Citizen Guyton has diſcovered, ſince the obſervation of Mr. Dehne, that we may eaſily combine together the oxide of zinc and ſulphur by

fuſion, and that the reſult of this proceſs was a mineral, or a ſort of grey ore, ſimilar to the ſulphuret of zinc of Huelgoët, from which priſmatic needles of a brilliant yellow colour were ſometimes raiſed and ſublimed upon the lid of the crucible. Hence he concludes, that blende contains the zinc in the ſtate of oxide, but that it differs from the artificial combination, being formed in the humid way, as appears from the water which it contains, whereas we are not yet able to form this combination artificially except in the dry way. Malouin has aſcertained that the liquid alkaline ſulphurets do not diſſolve zinc.

31. Zinc combines with ſeveral metallic ſubſtances; it refuſes to enter into alloys with cobalt, biſmuth, and nickel; when theſe metals are fuſed together, they are afterwards found ſeparated according to the order of their ſpecific gravity. Nothing is yet known concerning the reciprocal action of tungſten, molybdena, chromium, titanium, uranium, and mangaueſe, upon zinc. Its combinations with arſenic, antimony, and mercury, have been examined.

A. Malouin has found that metallic arſenic does not unite ſo well with zinc as its oxide or arſenious acid. However, by diſtilling a mixture of this acid, tallow and zinc, he obtained a blackiſh maſs, reſembling *blende,* but more tender. It appears, that when the arſenious acid unites with it, it yields its oxigen to the zinc, and again paſſes into the metallic ſtate. However, the experiments of Malouin on this combination ought to be reſumed.

B. Zinc and antimony eaſily combine and alloy with each other by fuſion; they form a hard alloy, with ſmall facets, and brittle, which ſeems to reſemble ſteel. The ſulphuret of antimony, fuſed with this metal, remains ſeparated from it.

C. Zinc unites with mercury even by trituration. According to Pott, this combination may be better made by uniting fuſed zinc with hot mercury; an amalgam is formed which eaſily becomes fluid by trituration. It cryſtallizes by ſlow refrigeration into ſquare laminæ, with level edges. It crackles over the fire. Several chemiſts aſſure us, that when it is waſhed in hot water, the zinc ſeparates from it in the ſtate of oxide. Moreover, it is thought, that zinc ſeparates antimony from mercury; and this accords with the difference of the degrees of adherence for this liquid metal which Citizen Guyton has pointed out; for antimony adheres to it only with a degree of force repreſented by 126, whilſt that of zinc is expreſſed by the number 204.

G. *Action upon Water and the Oxides.*

32. Zinc has a great tendency to decompoſe water, in conſequence of its great attraction for oxigen. Accordingly, this metal in the ſtate of powder, left even in the cold in contact with water in the upper part of a bell glaſs full of mercury, produces an effervefcence, forms a grey powder of oxide, and yields hidrogen gas. This action increaſes to ſuch a degree, and becomes ſo violent in high temperatures, that the effervefcence and ebullition produces dangerous detonations, as Lavoiſier has remarked. We ſhall ſoon ſee that this decompoſition takes place in many other experiments, and that on this account zinc is frequently employed by chemiſts for the purpoſe of obtaining the pureſt hidrogen gas which they are able to procure.

It is very remarkable that this oxidability of zinc by water is ſingularly augmented when we place it upon another metal whilſt it is plunged in this liquid. Thus when two plates of zinc are placed in two glaſs veſſels, the bottom of which is covered with a ſufficient quantity of water for the zinc to be immerſed in it, and when the condition of this metal is varied in ſuch a manner, that in one of the veſſels it is alone in contact with the water, whilſt in the other veſſel it reſts upon a plate or a piece of ſilver, the latter plate is covered, and as it were, enveloped with flakes of white oxide at the end of ſome hours; whilſt the plate of zinc that has been left alone, is either not oxidated, or exhibits only a ſlight appearance of oxidation.

33. This metal acts with much energy upon moſt of the metallic oxides, from which it takes away in a red heat the greater part of their oxigen. As it holds the ſecond rank after manganeſe, in the order of the attractions for this principle, it may be employed to decompoſe almoſt all the oxides; and as it is at the ſame time the metal which abſorbs oxigen in the moſt ſolid ſtate, it frequently inflames at the moment when it ſeizes upon this principle. Thus by rapidly heating, in a glaſs retort, a mixture of zinc in the ſtate of fine filings, or powder, with red oxide of mercury, we ſee at the moment when theſe ſubſtances become ignited to redneſs, a flame or ſparks which run through and fill the apparatus, and afterwards find the mercury reduced, and the zinc in the ſtate of oxide lining the ſides of the retort throughout.

H. *Action upon the Acids.*

34. There is no metal which exerts a more prompt action upon the acids, which decompoſes them, or the water which accompanies them, with greater activity, and which is diſſolved more abundantly in theſe bodies. The ſulphuric acid, diluted with water, and poured upon zinc in filings or in fragments, appears to attack it with force; a lively effervеſcence is produced ſuddenly and in the cold, and the mixture becomes much heated. A large quantity of hidrogen gas is diſengaged, which holds in ſolution a little carbon, but which however is one of the pureſt and lighteſt which the chemiſts are able to obtain. Accordingly, it is this gas which they employ for re-compoſing water in their exact experiments; and it is the ſame which, in the experiment which I made in 1790 with Citizens Sequin and Vauquelin, afforded us very pure water free from acid. The ſmall quantity of carbon, diſſolved in the hidrogen gas thus obtained, proceeds from the ſmall portion of carburet of iron contained in the zinc, of which I ſhall immediately ſpeak. It cannot be doubted that the water, decompoſed by this metal, which has great avidity for oxigen, is here the ſource of the gas, ſince the concentrated ſulphuric acid does not diſ-

ſolve zinc except with the aſſiſtance of heat, and ſince when decompoſed itſelf, in the ſtate of concentration, it affords ſulphureous acid gas. The water, therefore, in this caſe, effects the oxidation of the metal, and the oxide becomes diſſolved in proportion as it is formed in the ſulphuric acid, which, in fact, is found perfectly entire after the ſolution. In proportion as this ſolution takes place, we ſee a ſmall quantity of very black powder in a ſtate of extreme diviſion floating in the liquid, which has long been miſtaken by chemiſts, and which is nothing elſe than carburet of iron or plumbago, exiſting originally in the zinc, from which it ſeparates becauſe inſoluble. When the extrication of hidrogen gas has ceaſed, and the ſolution of the zinc is completed, the liquid has a ſingular ſmell, analogous to that of rancid fat; it is turbid and replete with a white powder, which gradually diſappears, and ſuffers the ſolution to aſſume a perfect tranſparency when we add water which diſſolves it. By evaporating it in a proper manner, and leaving it to cool, we obtain the cryſtallized ſulphate of zinc.

35. The ſulphate of zinc, ſufficiently pure and prepared in this manner, is white and tranſparent. It cryſtallizes in tetrahedral priſms, terminated by pyramids with four faces; the faces of theſe priſms are ſmooth, and have ſome reſemblance with thoſe of ſulphate of magneſia. This cryſtallization is not very difficult, and

when the ſalt is pure, it always ſucceeds well by the cooling of its ſolution a little condenſed by the heat. This ſalt has a pretty ſtrong acrid, ſtyptic, and metallic taſte. It is alſo prepared by diſſolving the grey or white oxide of zinc in ſulphuric acid, which, however, ſaturates itſelf with much greater difficulty than when the metal is gradually oxidated by means of water. When ſulphate of zinc is heated in a retort, it melts, loſes its water of cryſtallization, gives out a portion of its acid in the ſtate of ſulphureous acid and a little water; it dries and becomes in part decompoſed; ſo that when we afterwards attempt to diſſolve it again in water, a portion of oxide of zinc remains inſoluble. Expoſed to the air, the ſulphate of zinc efloreſces, and loſes its water of cryſtallization: it is decompoſed and precipitated in a white oxide by all the alkalis, and theſe precipitates, eſpecially thoſe that have been made by the carbonates, are capable of affording white pigments for painting. This precipitated oxide is ſoluble in the acids, and in an exceſs of the precipitating alkalis, eſpecially of ammonia. The ſulphate of zinc is alſo decompoſed with the aid of heat, by nitre, which it decompoſes at the ſame time: from this decompoſition, when made in a retort, there reſults nitric acid, in part nitrous, and ſulphate of pot-aſh mixed with oxide of zinc. The alkaline ſulphurets and the hidro-ſulphurets alſo precipitate the ſulphate of zinc in a deep orange or brown colour; ſulphurated and hidroſulphurated oxide of zinc are then depoſited.

36. There exiſts in commerce, under the names of *white copperas*, *white vitriol*, *Goſlar vitriol*, a ſulphate of zinc which is prepared in the large way at *Goſlar*. It is in the form of white maſſes granulated like ſugar, and often ſpotted with yellow. It is prepared by roaſting the native ſulphurated oxide of zinc or blende; treating this roaſted ore, already changed into ſulphate by the combuſtion of the ſulphur with an addition of water; decanting the clear liquor, then evaporating it, and cauſing it to cryſtallize ſuddenly by refrigeration, and laſtly, by fuſing the ſalt to deprive it of a portion of its water of cryſtallization, and obtain it in irregular, ſolid, and granulated maſſes. This ſalt exhibits all the properties of the ſulphate of zinc which has juſt been deſcribed; it differs from it only in being impure and containing ſulphate of iron: accordingly, when we diſſolve it and leave the ſolution expoſed to the atmoſphere, a red oxide of iron is ſeparated from it, and the cryſtals which we obtain have frequently a roſe-colour; which is a certain indication of the preſence of the latter metal, which is, beſides, proved to exiſt in it by the violet or black colour that the ſolution of this impure ſalt aſſumes, as ſoon as we add to it a ſmall quantity of nut-gall. It is alſo thought that this ſalt of commerce contains a ſmall proportion

portion of lead. In order to purify it, it is adviſable to put pieces of zinc into its ſolution, which precipitate the foreign ſubſtances. It is then very pure, and may be uſed for the ſame purpoſes as the artificial ſulphate of zinc, provided that the zinc employed in the preparation of this latter ſalt be perfectly free from iron, which will be the caſe when in preparing it, we take care to put more zinc into the ſulphuric acid then it is able to diſſolve.

37. The ſulphureous acid quickly attacks zinc in powder or in filings; a great production of heat takes place; ſulphurated hidrogen gas is diſengaged; the liquor firſt becomes brown; ſometimes it becomes turbid, and aſſumes the yellow colour of ſulphur; towards the termination of the action it becomes clear. This ſolution has a pungent, aſtringent, and ſulphureous taſte. The ſulphuric and muriatic acids diſengage ſulphureous gas from it with effervesſcence, and precipitate from it a yellowiſh white powder. The nitric acid firſt ſeparates ſulphureous gas from it, and afterwards a flaky, ductile, and adheſive precipitate. The precipitate is real ſulphur. When expoſed to the air, the ſulphureous ſolution of zinc thickens like liquid honey, affords needles or fine tetrahedral priſms with quadrangular and very ſharp-pointed pyramids, which become white in the air, and form a white powder inſoluble in water. Heated before the blow-pipe, this ſalt ſwells, emits a lively and brilliant light like that of

burning zinc, and riſes in the form of the branches of ſhrubs of a very agreeable appearance, or in tubercles ſurmounted by a multitude of other ſmaller tubercles: this is one of the moſt ſingular and moſt pleaſing ſpectacles that are preſented by the experiments made with the blow-pipe. It is partly ſoluble in alchohol: the part which has not been diſſolved, yields only ſulphureous acid gas by the ſulphuric acid, whilſt the part that has been diſſolved, at the ſame time that it yields the ſame gas by this acid, preſents an abundant precipitate of ſulphur. Diſtilled in a retort, the ſulphite of zinc affords water, ſulphureous acid, ſulphuric acid, ſublimed ſulphur; there remains ſome oxide of zinc mixed with a ſmall quantity of ſulphate of this metal. The yellow powder, ſeparated from this ſalt by the acids, burns with a blue flame upon ignited coals; it is diſſolved into a brown ſulphuret by the liquid alkalis. Thus this ſalt is a ſulphurated ſulphite of zinc: in its ſolution by the liquid ſulphureous acid, the metal has decompoſed the water, and a portion of the ſulphureous acid itſelf, ſince ſulphurated hidrogen gas is diſengaged; the ſulphur that is ſeparated is not precipitated during the ſolution, but combines with the ſulphite of zinc; this, however, is not ſaturated, ſince the alchohol, whilſt it diſſolves only the portion of ſulphurated ſulphite which it contains, ſeparates from it ſulphite of zinc.

38. As zinc is one of the metals which preſent, with the greateſt energy, the very remarkable properties of a double combination with the ſulphureous acid; and as theſe combinations have not yet been properly deſcribed, or even indicated by chemiſts, I ſhall here give a ſomewhat circumſtantial account of a ſecond ſpecies of ſalt or ſulphite of zinc that is not ſulphurated like the preceding. It is the reſult of numerous experiments which I have made in conjunction with Citizen Vauquelin, which I am about to offer, as it throws much light upon compounds hitherto unknown, which, it is nevertheleſs, very uſeful to the progreſs of chemiſtry to diſtinguiſh. I have already indicated their baſes in the firſt article of this ſection.

When the white oxide of zinc is mixed with ſulphureous acid highly concentrated, theſe two bodies combine without motion, with a production of heat, and a deſtruction of odour on the part of the acid. When the ſaturation is complete, white imbricated cryſtals are formed upon the ſurface of the liquor. This ſalt or pure *ſulphite of zinc*, compared with the preceding, or the *ſulphurated ſulphite of zinc*, preſents the following properties:

a. It has a leſs pungent, but more ſtyptic taſte than the latter.

b. It is leſs ſoluble in water, and cryſtallizes more eaſily.

c. The acids hitherto known, or with ſimple radicals decompoſe it with effervеſcence, but they do not ſeparate from it any ſulphur, as from the ſulphurated ſulphite.

d. It is inſoluble in alcohol, whilſt the preceding is entirely, and even abundantly ſoluble in it.

e. It forms white precipitates with the alkalis, whilſt the ſulphurated ſulphite affords yellowiſh precipitates.

f. Expoſed to the air, it is ſpeedily converted into ſulphate of zinc, whilſt the ſulphurated ſulphite may be expoſed to the air for a great length of time without undergoing any alteration.

g. The precipitate which the ſulphite of zinc yields by the alkalis is completely ſoluble in the cold in ſulphuric acid; that furniſhed by the ſulphurated ſulphite is only partially ſo, and leaves pure ſulphur after the ſeparation of the oxide of zinc by this acid.

h. All the properties of this ſulphite of zinc are changed, and ſulphurated ſulphite is formed, when inſtead of diſſolving pure oxide of zinc in ſulphureous acid, we treat a mixture of ſulphur and oxide of zinc with this acid in the heat. However, it is leſs ſulphurated by this operation than that which is prepared with zinc and ſulphureous acid, ſince in the latter caſe, the zinc, whilſt it decompoſes the ſulphureous acid, and ſeparates the ſulphur from it, unites with it more intimately and more abundantly, on account of its great ſtate of diviſion.

39. The concentrated nitric acid is capable of inflaming zinc: in order to effect its ſolution, this acid muſt be taken in its weak ſtate, and the zinc in rather coarſe fragments. A conſiderable heat is produced; the effervefcence which accompanies the ſolution, gives riſe to a diſengagement of a large quantity of nitrous gas, which reddens ſuddenly and ſtrongly with the air when the operation is performed in open veſſels; by this means a large quantity of nitrous gas may be collected. Thus the zinc rapidly decompoſes the acid of the nitre, and takes oxigen from it. When this metal contains iron, this is ſeparated at the ſurface of the ſolution in the form of a reddiſh oxide; when it is pure, it leaves only a ſmall quantity of black powder of carburet of iron, like the ſulphuric acid. The oxide of zinc, in proportion as it is formed, diſſolves in the nitric acid, which even takes up much more of it than the ſulphuric acid. This ſolution is frequently of a greeniſh yellow colour; it is very cauſtic, though made with an acid diluted with water. By evaporation and refrigeration, it affords cryſtals in tetrahedral compreſſed and ſtriated priſms, terminated by pyramids with four faces. This ſalt melts upon the coals, and becomes fuſed with crackling, in the part which is deſiccated. Dur-

ing its detonation it emits a ſmall reddiſh flame. When fuſed in a crucible, it quickly affords an extrication of red vapours; it aſſumes a deep colour and a gelatinous conſiſtence. When cooled in this ſtate, it retains its ſoftneſs for ſome time. By continuing to heat it, it becomes dry, affords nitrous and oxigen gas, and leaves a yellowiſh oxide. Hellot had inſiſted upon the nitrous acid extracted from this ſalt, and the red colour which it aſſumes during its fuſion. The nitrate of zinc attracts the humidity of the atmoſphere, and loſes its form. It is perfectly decompoſed by the ſulphuric acid; the alkalis precipitate from it a white oxide which they re-diſſolve, and the alkaline carbonates produce, by precipitation, a very white carbonate of zinc. The nitrite of zinc is not known, though it is very probable that the nitrate, after being heated, and having aſſumed a red colour, is in this ſtate.

40. The muriatic acid acts upon zinc with much rapidity; it diſſolves it, producing a briſk efferveſcence and a diſengagement of very pure hidrogen gas; it therefore, powerfully promotes the decompoſition of water by this metal. In proportion as the oxidated zinc diſſolves in the muriatic acid, a black powder of carburet of iron is ſeparated. The muriatic ſolution of zinc is white and colourleſs; it affords no cryſtals, how far ſoever we may carry the evaporation; but it is reduced to a tranſparent and

ſoft maſs like a jelly. In diſtillation, it yields a ſmall quantity of very fuming acid, and a ſolid muriate of zinc fuſible in a gentle heat, which was formerly termed *butter of zinc*. This muriate of zinc, when ſublimed and congealed, is of a beautiful white colour, conſiſting of ſmall priſms adhering the one upon the other. It is decompoſable by the ſulphuric acid, which diſengages the muriatic acid from it in the form of vapour or gas. The alkalis precipitate it of a white colour; water does not precipitate it; it gradually attracts the moiſture of the atmoſphere, and ſoon forms a tranſparent jelly. It is alſo obtained by decompoſing the ſuper-oxigenated muriate of mercury by means of zinc.

41. When zinc is thrown in the ſtate of powder into oxigenated muriatic acid gas, it inflames, and forms a white oxide as well as by the nitric acid. It is afterwards ſoluble in the muriatic acid, and forms the ſame ſalt as is produced by the ſolution of zinc in this acid in its ſimple ſtate. The liquid oxigenated muriatic acid diſſolves zinc without motion and without efferveſcence; for this metal becomes oxidated by quietly taking oxigen from it, and unites in proportion as it is oxidated with the diſoxigenated muriatic acid. This ſolution does not differ from that of the metal, or its oxide in the ſimple muriatic acid. We are not yet acquainted with the ſuper-oxigenated muriate of zinc, which appears to be reproduced when we treat the muriate of zinc with the oxigenated muriatic acid.

42. The phoſphoric acid diluted with water attacks zinc, with a diſengagement of hidrogen gas, which is owing to the decompoſition of the water; we ſoon ſee a white powder formed, which is depoſited, and is the phoſphate of zinc. We alſo obtain it in a white precipitate, owing to the effect of a neceſſary double attraction, when we pour into a ſolution of ſulphate, of nitrate, or of muriate of zinc, that of the phoſphates of pot-aſh, of ſoda, or of ammonia. We are not yet acquainted with the characteriſtic properties of the phoſphate of zinc. This metal, when heated ſtrongly with the vitreous phoſphoric acid, reduces a portion of it into phoſphorus, with which it combines into phoſphuret of zinc.

43. The combinations of the fluoric and boracic acids with zinc have not yet been examined. The firſt attacks it with effervefſcence and a diſengagement of hidrogen gas. The ſecond attacks it but very feebly by immediate contact, but it combines with its oxide when the nitric or muriatic ſolution of zinc is poured into the ſolutions of borate of pot-aſh or of ſoda. The diſtinguiſhing properties of the borate of zinc have not been examined; we only know that it is inſoluble in water.

44. Zinc thrown in the ſtate of a fine powder into liquid carbonic acid, is oxidated and diſſolved in ſufficient abundance after remaining twenty four hours in this acid, for a pel-

licle of carbonate of zinc, of different colours, to be formed upon the ſurface of the ſolution expoſed to the air, according to Bergman. This is undoubtedly the manner in which nature prepares the carbonate which is found in the ſecondary ores of this metal. Nothing can furniſh a better proof, than this ſolution of zinc in water charged with carbonic acid, of the great tendency which this metal has to combine with oxigen, and the property which it poſſeſſes of eaſily decompoſing water; for though no effervefcence is here obſerved, it cannot be doubted that hidrogen gas is diſengaged, as may be perceived from the ſmell of the ſolution.

45. The arſenic, tungſtic, molybdic and chromic acids are ſuſceptible of combining with the oxide of zinc, which, in the metallic ſtate, decompoſes them and robs them of their oxigen. Hitherto the arſeniate, the tungſtate, the molybdate, and the chromate of zinc have not been obtained unleſs by double attractions, by precipitating the nitrate of zinc by the combinations of theſe acids with alkalis. Theſe ſalts are depoſited in the form of powder, becauſe they are inſoluble in water; the three firſt are white, and the chromate of zinc is of an orange-red colour. Theſe compounds are deſtroyed by the preceding acids in the inſulated ſtate.

I. *Action upon the Baſes and the Salts.*

46. AMONGST the ſalifiable baſes we are yet acquainted only with the action of the alkalis upon zinc. When we plunge it into ſolutions of pot-aſh, or of ſoda, it becomes tarniſhed; its colour blackens; and even when theſe liquors are boiled a ſmall quantity of hidrogen gas is diſengaged; the alkalis then aſſume a dirty yellow colour, and a white oxide of zinc may be precipitated from them by means of the acids.

Ammonia, according to the experiments of Laſſone, acts ſtill more powerfully upon this metal in the cold; more hidrogen gas is extricated; the oxide thus formed is diſſolved more abundantly in the liquor, and after ſome time, a large quantity of this white oxide is ſeen at the bottom of the volatile alkali. Theſe alkaline ſolutions become turbid by expoſure to the air, the oxigen and carbonic acid of which, acting at the ſame time, precipitate the oxide. This is another proof of the ſtrong attraction of zinc for oxigen, and of the facility with which it effects the decompoſition of water, aſſiſted only in this caſe by the action of the alkalis.

47. Zinc decompoſes the alkaline and earthy ſulphates by the aid of heat. It ſeizes the oxigen of the ſulphuric acid, and reduces it

to the ſtate of ſulphur which combines with the baſes of the ſulphates. Theſe ſulphurets, when once formed, combine, though not without difficulty, with the oxide of zinc; and when this fuſed maſs is lixiviated, the water diſſolves the ſulphurets, which hold only a very ſmall quantity of oxide of zinc in ſolution. The greater part of the oxide remains pure and inſulated after this action of the water. Pott has obſerved, that zinc decompoſes alum by ebullition: in this caſe a triple ſulphate of zinc and alumine is formed.

48. The nitrates burn zinc briſkly with the aid of a red heat; their acid is decompoſed; the oxigen ſeizes the metal with which it unites in a more ſolid ſtate and more intimately than was the caſe in the nitric combination; hence the activity and the luſtre of the detonation and flame which accompany this rapid combuſtion. The azote is diſengaged in the form of gas, and the reſult of this operation is an oxide of zinc at the *maximum* of oxidation, combined in part with the baſe of the nitrate which has been employed. Moſt commonly the nitrate of pot-aſh is uſed for this combuſtion; three parts of it, well dried are mixed with one part of zinc in fine filings, or even in powder paſſed through the ſieve; this mixture is thrown into a crucible heated to redneſs; the radiance of the inflammation which immediately takes place is ſuch, that it throws

out to a great diſtance from the veſſel portions of burning matter, with flaſhes, and a very brilliant light; it is therefore neceſſary to operate with caution. The oxide of zinc, which is the product of the operation, is found united with the pot-aſh; and when we lixiviate this reſidue, the water diſſolves a portion of it with the alkali; ſo that we may aſcertain its preſence by pouring an acid into this lixivium. Hellot aſſerts that this liquor was conſidered and preſcribed by one Reſpour, a ſkilful alchemiſt, as a ſpecies of alcaheſt, or univerſal ſolvent of metals. The beauty of the flame of the ſpectacle afforded by this rapid combuſtion of zinc by the nitrate of pot aſh, has rendered it one of the ſubſtances employed by artificers in the conſtruction of fireballs which fly into the air, and throw out thoſe white flames, thoſe brilliant ſtars, whoſe beautiful light illuminates ſo large a ſpace in the firmament.

49. Though the action of zinc upon the muriates is more feeble than its action upon the preceding ſalts, it is far from being inconſiderable. Pott has deſcribed ſome experiments which ſeem to prove that this metal is capable of decompoſing the muriate of ſoda. Macquer obſerved that when triturated with the ammoniacal muriate, it diſengaged the ammonia from it, even in the cold. Bucquet has obſerved, that by diſtilling this ſalt with zinc,

ammoniacal gas and hidrogen gas were obtained. The latter product can only be owing to the decompoſition of the water contained in the ſalt, by the zinc, which affects it before it combines with the muriatic acid. The reſidue of this operation is muriate of zinc, which may be ſublimed by a ſtronger heat. According to Hellot, the oxide of zinc produces the ſame ſeparation of the principles of the muriate of ammonia.

50. The phoſphates and the borates melt with zinc, and combine by fuſion with its oxide, which gives to their glaſs a greeniſh yellow tinge. No decompoſition of theſe ſalts is effected by the metal. Whatever attraction it has for oxigen, it cannot act, no more than charcoal can, upon the phoſphoric acid combined with the earthy and alkaline baſes, which, as we have ſeen in the preceding ſection, is powerfully fixed by theſe baſes.

51. Zinc decompoſes moſt of the ſalts and metallic ſolutions by its ſtrong attraction for oxigen; it precipitates from them the metals in the metallic form by completely unburning them, or in that of oxides leſs oxidated than they were before. It is very uſeful in the analyſes of ores on account of this property. Its oxide has alſo more attraction for the acids than moſt of the others.

K. *Uſes.*

52. Zinc is applied to uſes no leſs numerous than important in a great number of the arts. It forms a part of many conſiderably hard and white alloys. It is particularly employed in the fabrication of tombacs and braſſes, of which we ſhall ſpeak elſewhere. The eaſtern nations, and eſpecially the Chineſe make uſe of it, as has already been obſerved, much more frequently than the Europeans; undoubtedly, becauſe they poſſeſs it in greater abundance than we do, and perhaps, becauſe they are better acquainted with its uſeful properties. It has been propoſed for lining copper: concerning this application we ſhall have occaſion to ſpeak in the hiſtory of the latter metal. Malouin, in his Memoirs inſerted amongſt thoſe of the Academy for 1743 and 1744, has compared zinc with tin with relation to its economical properties, and has frequently given it the preference.

53. Zinc and its chemical preparations have already been applied to medicinal purpoſes, Its property of conducting ſo great a degree of animal electricity, may hereafter render it much more valuable to the healing art. Formerly, the ſulphate of zinc was employed as an emetic, under the name of *gilla vitroli.* The oxide of zinc prepared in the pharmaceutical laboratories, is preſcribed as an antiſpaſmodic,

in doſes from half a decigramme, one grain, to that of ſeveral decigrammes at moſt. It has been much extolled in the convulſive diſeaſes of children, and was at firſt adminiſtered as an arcanum, under the name of fixed luna, by one Ludemann, in Holland. Gaubius, who examined this remedy, found it to be nothing more than oxide of zinc, which was then termed *flowers of zinc* This oxide, and eſpecially tutty and ſulphate of zinc are employed as very good external remedies in diſeaſes of the eyes.

END OF THE FIFTH VOLUME.

W. Flint, Printer,
Old Bailey.

The morning came Miss Pride aros
and straightway to her window gu
but saw a dark the land scape ~~shroud~~ shro
Composed of big portentous clouds
Without imagination sketch
A perfect water colour sketch

Our Cheerful friend at breakfast met
Held out some hopes of pleasure yet
And hoped the minda ~~morn~~ ~~morning~~ sun would find
Wither propitious to her mind
Wrapped up in suits of water proof
They got beneath the Church's roof
And nothing else they did that day
but what they ought to watch & pray

Tedious would be to didalute all ~~that happend~~
that happened so I'll dilute

While she remained it constant rain
One Monday eve she took the train
nor cared no longer to remain

The day [illegible] [illegible] [illegible]
But [illegible] the [illegible] [illegible]
[illegible]
[illegible] —
[illegible]
Compared [illegible] [illegible] Clouds —
[illegible]
[illegible] ~~[illegible]~~ [illegible] —
~~[illegible]~~ —
[illegible]
[illegible]
[illegible]
[illegible]

[illegible]

In the far fair
what I'll do now
It was [illegible] more to be sorry —
~~Her~~

~~[illegible]~~

[illegible]
~~[illegible]~~
~~all [illegible]~~
[illegible]
[illegible]

~~[illegible]~~
~~[illegible]~~
[illegible]

And strange to say when she set out
The heavenly system ceased to spout
As I'll do now
The Heavens cleared the sun shone ou

But

But

She

She prov

She showed the ... her ...
But could not escape ... the ...

The [illegible] Canoe

The [illegible] [illegible] [illegible] [illegible]
~~[illegible]~~

~~[illegible]~~

The [illegible] [illegible] [illegible] [illegible]